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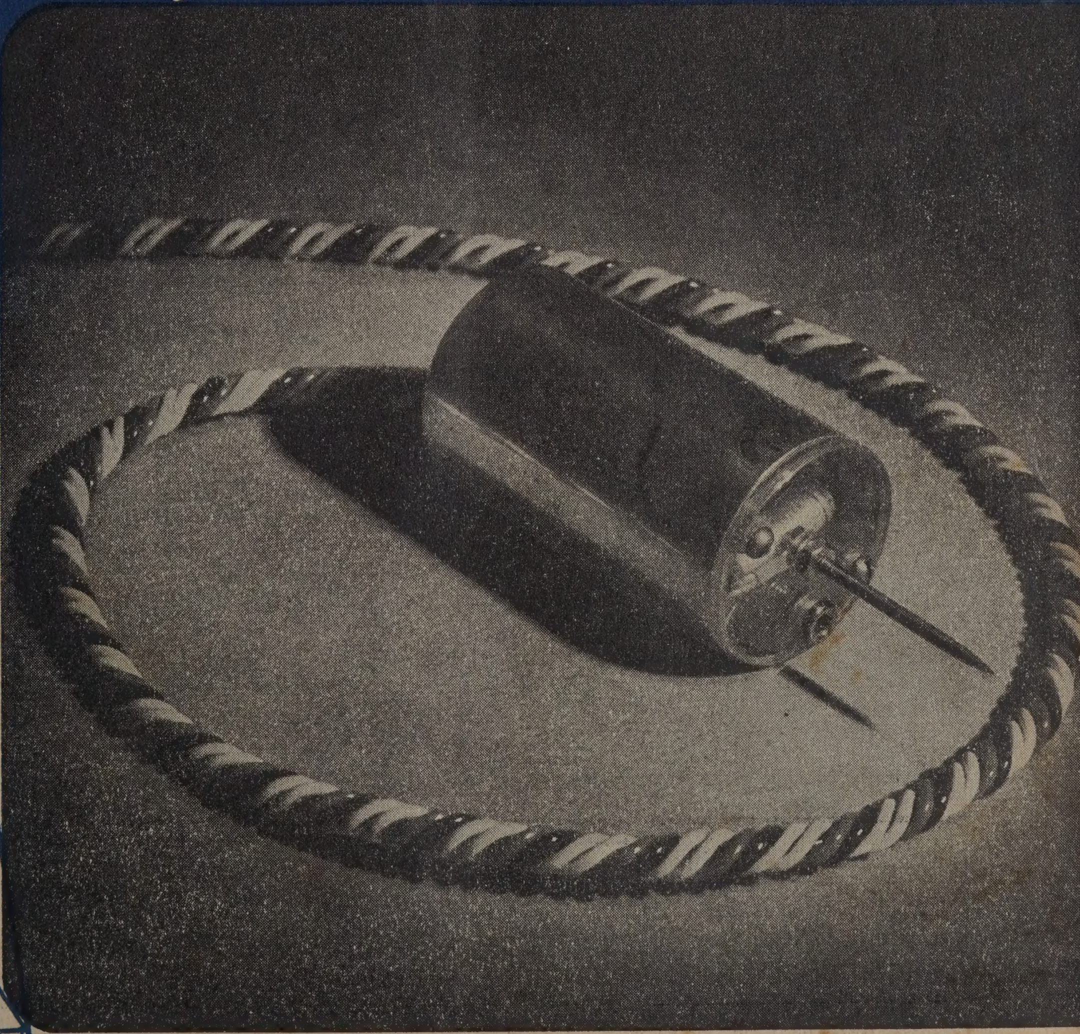

In this issue: AN EXCELLENT V.T. VOLTMETER

MAY 1st, 1951 VOL. 6, NO 2 1/10

RADIO and ELECTRONICS

Vol. 6, No. 3 — 1st MAY 1951

OUR COVER

The photograph illustrates the completed probe of the V.T. voltmeter, the description of which is commenced in this issue. Although its circuit is simple and contains few parts, the stability and accuracy of the meter are excellent. The diode probe illustrated enables measurements to be made at very high radio frequencies.

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WANTED - Trained Technical Personnel

The expansion of a relatively new field of endeavour, such as electronics undoubtedly is, depends largely, in a given place, on the number of skilled engineers and technicians that are available. The New Zealand radio industry, even at the present time, is short of such personnel, and possible future events can only increase the shortage, unless something is done about it. Not only is it possible that in a very few years the manufacture and maintenance of television receivers will be added to the industry's present endeavours, but the normal development of radio services generally, and the expanding use of electronic equipment in a wide variety of industries, will create a need for more men whose knowledge and attainments will have to be high, by present-day standards, if their functions are to be satisfactorily carried out.

The same sort of thing has happened, and is happening, elsewhere. Both in Britain and America, the impetus given to the electronic industry by television, and other modern applications of electronics has led to a shortage of trained men, and it will be a very surprising thing indeed if something of the same nature does not happen here.

One of the greatest difficulties in attempting to entice more young men into the industry is that there is no professional standing attaching to most technical jobs within the industry. This being the case, it is difficult to show a boy leaving school why he should enter the industry, for it is not possible to hold out any more hope for him than that he should pass through an apprenticeship, after which he may be able to earn a good deal less than any unskilled labourer. If one is honest, he can be assured that by taking this course he will certainly never earn more!

What other avenues of approach are available? If the boy is of greater than average ability, and is well advised, he may go to university, take a science degree in radio-physics, or one in electrical engineering, and then, after years of expensive preparation, find that the only positions available which will make use of his attainments are those in Government departments. This may not worry the young man himself, because he is usually sufficient of an enthusiast to be glad of work that is interesting, and in his own particular line, but it should worry the radio industry!

There seems to be a curious reluctance among the industry to employ university graduates, either in a purely technical capacity, or in a combined technical-cum-commercial role. One answer to this is that young graduates expect a high salary, and often have little to commend them save a good background of theory. Surely this is not an answer at all. Degreed men, if they are employed at all, should be entitled to more per week than the boy who left secondary school after two years to take up lucrative but unskilled jobs like lorry driving. Nor have we, or anyone else for that matter, said that a man is good for a certain job just because he has a degree. Far from it. What we do say, is that a good man with a degree behind him cannot fail to be a better commercial proposition than another, equally good in other respects, but who has not the theoretical background that a degree implies.

The radio industry should, for its own good, do something active to encourage university graduates of the right kind, and with the right qualifications, to join its staffs. It may think that it has no place for such men, and in some cases this may be true, because the positions that might be held by them are filled by men who have grown up with the industry almost from boyhood, and who hold their positive by virtue of long practical experience rather than by formal qualifications. These men are extremely valuable, and no one in his senses would suggest that they should not hold their positions because they do not hold degrees. But time has already marched on, and these old hands will before long have disappeared; from where are they to be replaced? They should be replaced, when the time comes by young men of the kind we have been discussing. Those responsible should not make the mistake of believing that because the "old hands" were so good without formal training, then formal training is not needed. It is the time factor that counts, as ever; for a young man, suitably trained *before* engagement, can, if he is a capable youth, be brought to the required standard more surely, and in a tenth of the time than can one who has no formal background.

Another "DIGEST OF CIRCUITS"

Approximately two years ago, we made what we considered to be a rather bold experiment, in reproducing under one cover, all the practical circuits, with the remaining essential constructional data, that had been published in *Radio and Electronics* over a period of more than two years. This volume, under the title of "R. and E." Digest of Circuits, proved even more popular among radio enthusiasts than we had hoped, with the result that the whole edition was sold out within a matter of weeks. It was not possible to make a second impression, so that many would-be purchasers were disappointed.

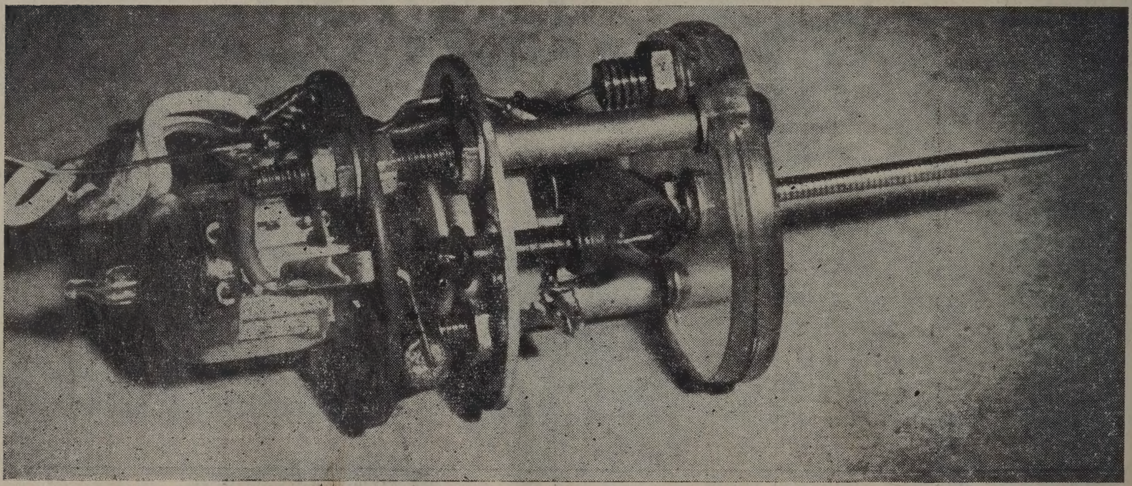
In approximately a month's time, a second volume of the same nature will be published. It will be of the same size as formerly, and of the same general make-up, but will contain digested material from monthly issues of *Radio and Electronics* since December, 1948, which was the last issue to be included in the first Digest. Thus, all material in the new book will be new to those who may not be regular readers of this periodical, and who may have the original Digest. As before, we hope, regular readers will find the collected volume of circuits well worth having as a reference book, since each item is referred in the text to the issue of *Radio and Electronics* in which it originally appeared. In cases where the original article was in two or more parts, all relevant issues are referred to.

The title will be "The 'R. and E.' Digest of Circuits" and will be printed in blue, on a new photographic background design, so that it may easily be distinguished from the original Digest.

We regret very much, however, having to end this announcement in the same vein as so many others these days—by announcing an increase in price. Our costs have risen, in common with everyone else's, and investigation showed that without increasing the selling price, it would not have been possible to produce the book at all. The "1951 Digest" will sell for 3s. 6d. and we trust that readers will agree with us when we think that this is a very small sum to pay for such a quantity and variety of technical information.

A SIMPLE AND INEXPENSIVE VACUUM-TUBE VOLTMETER

We have for some time been requested to publish the design for a V.T.V.M. that is reliable, accurate, easy to construct, and not too expensive. The instrument described here comes as close to fulfilling all these requirements as anything we have yet seen, and has advantages not possessed by many more costly and complex arrangements. It uses a diode probe for A.C. measurements, and can be employed at very high frequencies or at audio frequencies without any circuit changes.



This photograph shows the inside "works" of the probe built for the V.T.V.M. This probe is an integral part of the circuit, and drawings showing its construction will be featured in the second instalment of this article.

INTRODUCTION

The vacuum-tube voltmeter is such a useful instrument as to be almost universally desired at one time or another by experimenters and professional radio workers, but has always suffered from several disadvantages which between them, tend to neutralize its many theoretical advantages. Commercial instruments are expensive, are not always blessed by good accuracy, and suffer from miscellaneous defects which often make them extremely annoying to use. The instrument we are about to describe, however, is so designed that the inherent defects are negligibly small in magnitude, so that the instrument is quick and easy to use, without a great deal of fiddling with the zero adjustment, which remains remarkably steady after the initial warm-up period has passed. The circuit, moreover, has the great virtue of simplicity and ease of adjustment. It is not costly to build either as the most expensive part of it—the meter movement—is specified as 0–500 μamps, and can well be one of the inexpensive meters of this description that are available from war surplus sources. These meters, of course, have only a small scale, and a large meter would be an improvement, since it would be easier to read, but the accuracy of the small meters that are available is very good, making them very suitable except in this one respect.

BASIC REQUIREMENTS

What, then, are the basic requirements that must be fulfilled if we are to produce a satisfactory valve voltmeter?

First, perhaps, comes a satisfactorily large range of measurement. One of the difficulties of V.T.V.M. design is the production of a simple and reliable method of extending the useful measurements over a wide enough range. The present instrument has full-scale deflections of 0-3, 0-10, 0-100, and 0-300 volts, and the only requirement for including extra ranges, should they be needed, is one extra resistor (or possibly two) and an extra position on the simple single-pole range switch.

Next in order of importance is stability of zero-setting, or zero stability, as it is often called. All V.T.V.M.s have a panel control whose purpose is to set the pointer to zero on the scale before any measurements are taken. The instructions provided with the instrument usually specify that the input terminals should be short-circuited while the zero is set, after which it is ready for use. In a perfect instrument, once the zero had been set in this manner, it would remain so however long the instrument was in use, but in many meters, the zero setting exhibits appreciable drift, and in bad cases, requires re-setting before every reading is made. This severely limits the usefulness of the meter, on account of the time taken to remove the meter from the circuit and carry out the setting procedure.

A further important practical point is the existence of what is called zero error, as distinct from zero stability. Zero error may be defined as a change in the zero setting which occurs when the meter is switched from one measuring range to another. It often happens that the zero has to be re-set every time the range switch is shifted, but in the present instrument, not only is the zero stability very good, but zero error is non-existent and cannot possibly occur, because of the design of the circuit.

FEATURES OF THIS INSTRUMENT

Apart from the excellent coverage of voltages from about one volt to 300, with ample overlap between ranges, the meter to be described has the following features that will recommend it to many of our readers:

(1) Low Cost

Apart from the meter movement itself, it can be built for a very small expenditure of cash, the most expensive item being a midget instrument type power transformer. If a war surplus meter is used, the total cost is low, while even if a larger meter is purchased specially for the job it need not cost more than ten pounds all told.

(2) Stability

After a warm-up period of about ten minutes, the zero setting does not shift by more than one per cent. of full-scale deflection, however long it may be in use. The zero setting, and also the readings, are quite unaffected by variations in the supply voltage, as shown by the fact that a change of 100 per cent. in H.T. voltage produces no more than a barely discernible movement of the pointer—no more than a pointer's width. Nor do variations of heater voltage affect it, so that there is no need at all for a stabilized mains supply, or a regulated H.T. voltage.

(3) Zero Error

As explained above, zero error is completely absent.

(4) Frequency Range

No tests have as yet been undertaken to estimate the maximum usable frequency of the meter, but a 6AL5 diode is used, which should give accurate readings up to at least 100 mc/sec., and useful indications much higher than this, especially since an R.F. probe is used, with the diode mounted in it so as to reduce R.F. losses, and to make lead lengths carrying R.F. as short as possible.

(5) Range Overlap

Generous overlapping of the ranges has been provided so that all readings can be taken on the upper half of the scale, and there is no necessity for reading any voltage, except on the lower part of the lowest range, at very small pointer deflections. This increases the accuracy with which measurements can be taken.

(6) Linearity

On all but the lowest range, the linearity of the indication is excellent. No observable departure from complete linearity is found on any range except the 0–3v. range. This non-linearity of the lowest voltage range is common to all V.T. voltmeters, and arises through the inherently non-linear rectification characteristic of all diodes at very small input voltages. However, even on the 0–3v. range, the indication is sensibly linear down to 1v., so that there is really no need for a separate scale calibration on the lowest range.

(7) Ease of Calibration

On account of the excellent linearity, calibration of the meter is very easily accomplished. This is due partly to

the fact that the sensitivity is entirely determined, on each range, by the value of one adjustable resistor. In the prototype, all ranges were individually checked, but the overlap is so wide that it would be quite practicable to calibrate the meter solely at its maximum reading, viz., 300 volts, and then to calibrate all the lower ranges from the already fixed 300-volt range. In any case, calibration consists only of adjusting the calibrating resistor for the range in question so that the meter reads full scale when the appropriate input voltage is applied.

THE CIRCUIT

The full circuit of the meter is shown in Fig. 1. As can be seen, the circuit proper uses only two valves, both of them readily obtainable and likely to remain so. The third is the rectifier, which is a 6X5. All the parts contained within the dotted line are housed inside the probe, a photograph of which appears on the front cover of this issue, and of which an inside view is given on the first page of this article. The principles of the instrument are, however, better illustrated by the skeleton diagram of Fig. 2. V_1 is the rectifier diode, to which the A.C. input voltages are applied. It uses a peak rectifier circuit, so that a D.C. voltage is developed across the load resistor that is directly proportional to the *peak* value of the input voltage. This D.C. voltage is applied directly to the control grid of V_2, which is a triode, operating with its sole load resistance in the cathode circuit, and thus with 100 per cent. negative feedback. It is because of this feedback that the linearity of the instrument is good. The application of a negative control voltage to the grid by the diode reduces the voltage drop across the cathode resistor of 47k. in strict proportion to the voltage input. It would, of course, be possible to obtain an indication simply by placing a D.C. meter in series with the cathode load resistor of V_2, but this would have several disadvantages. The purpose of the remaining two tubes is to remove these obstacles, so that some explanation of what they are is necessary in order to describe the functions of V_3 and V_4.

In the first place, a meter in series with the cathode load resistor of V_2 would read approximately 3 ma. when no signal was applied to the diode. When a voltage was applied, the meter would show less current, and so would make it necessary in the first place for the meter to be adjusted to full-scale reading, and then to be scaled backwards, much in the same way as an ohmmeter. A further disadvantage would be that the useful part of the scale would not extend to very low meter readings, because even the cathode follower circuit exhibits non-linearity at very low plate currents.

In order, then, to dispose of these disadvantages, a third tube, V_3, is inserted. It is identical in characteristics and circuit values with V_2, and as a result, passes exactly the same plate current, as long as its electrode voltages are the same as those of V_2. Now under no-signal conditions, there is a voltage drop of about 140 volts across the 47k. cathode resistors if the tubes are passing a plate current of 3 ma., so that if the grids were returned to the negative end of the power supply, the tubes would be very heavily biased by the large cathode resistors, and would not pass 3 ma. at all. For this reason, the grid return leads of both triodes are joined together and taken to a positive tap on the power supply. If this positive voltage is high enough, the tubes automatically adjust themselves until the correct operating conditions obtain, and they are passing the required plate current. Now the circuit is such that on receipt of a signal, this is applied to the grid of V_1, but *not* to the grid of V_2. For this reason, the only occasion on which the two triodes work under the same conditions is when there is no signal

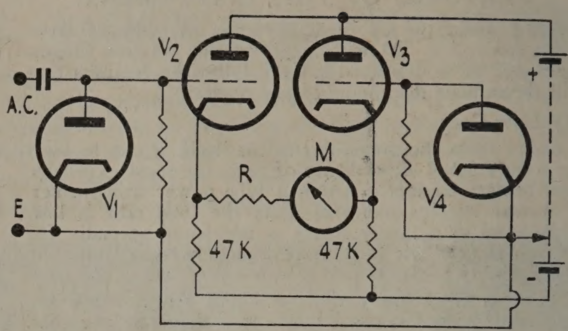
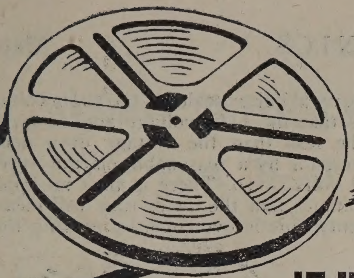


Fig. 2.—Basic circuit of the V.T.V.M. In practice, V_1 and V_4 are halves of a 6AL5, and V_2 and V_3 are halves of a 6SN7.

applied to the grid of V_2 from V_1. Now, since both tubes are then passing the same plate current, the voltage drops across the equal cathode resistors must be the same, and there will be no difference between the voltages at the cathodes of the two tubes. It is thus possible to connect a voltmeter between the cathodes, without disturbing the operating conditions of either valve, and *without passing* any current through the meter, which therefore reads zero.

But when a signal is passed to the V_2 grid, no corresponding signal is applied to the grid of V_3, so that there is a difference of potential between the two cathodes, and current will flow in the meter circuit. It is now only a matter of connecting the meter in the correct polarity for it to read upwards in the proper manner when signal is applied. The fact that the circuit is inherently a balanced one accounts for the excellent zero stability, and also for the fact that the zero does not change appreciably with changes in plate supply voltage or of heater voltage. Because of the large negative feedback, quite large differences in the supply voltages, or in the characteristics of the valves themselves have very little effect on the cathode currents of V_2 and V_3, and because any changes in supply voltages affect both tubes to the same extent, no change in meter reading results.

The function of the second diode, V_4, has not yet been explained. First of all, it is necessary to know that a diode rectifier circuit such as the one used here, produces a negative output of about one volt, even in the absence of a signal. This is called contact potential, and is due to the fact that some electrons reach the plate, because of the initial velocities with which they are ejected from the cathode, even when there is no positive D.C. voltage applied to the plate. In many V.T. voltmeters, this contact potential changes on the different measuring ranges. It is this, in fact, that causes a good deal of the zero error in many instruments. In addition, contact potential depends very much on the heater voltage of the tube, and so varies in amount quite considerably as mains voltage fluctuations occur. The contact potential therefore is a prominent cause of poor zero stability in instruments where regulation of the A.C. power input is not applied. But regulation of A.C. is expensive, and it is very desirable, if it can be done, to remove the need for the regulation. This is where V_4 comes in. It is, in practice, the second diode of a double diode valve. It uses the same heater winding as does V_1, and so is subject to identical voltage fluctuations. Its contact potential is applied to the grid of V_3, so that the whole circuit is balanced, not



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only with respect to the triode stage, but also with respect to the diode contact potentials.

THE FULL CIRCUIT

We can now examine the full circuit of Fig. 1, and see what differences there are between this and the basic circuit of Fig. 2. The first thing to note is that instead order to preserve a linear scale at the high voltage end. The trouble is that the D.C. voltage applied to the grid of V_2 must be less than the voltage drop across the cathode load resistor by a reasonable margin—preferably by at least 20 volts or so. There is thus an upper limit to the D.C. voltages that the meter tube will measure. In some instruments, this is overcome by making the range

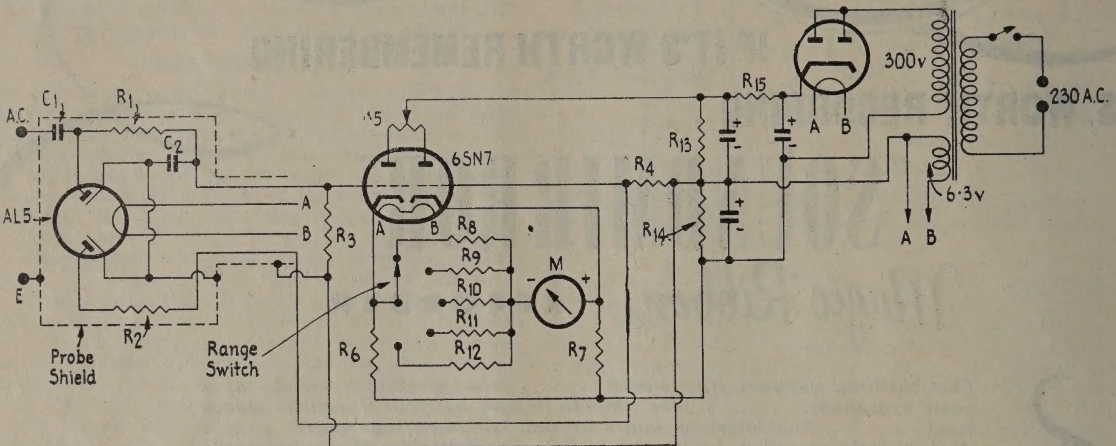


Fig. 1.—Full circuit of the instrument.

of applying the whole D.C. output of the rectifier diode to the grid of V_2, a voltage divider is employed, consisting of a 15 megohm resistor in series with 10 megohms. Thus only 0.4 of the diode output voltage is applied to the meter valve. This reduces somewhat the maximum sensitivity which it would be possible to obtain from the circuit, but this is unimportant, as it is still possible to make the low range read 0–3 volts, as indicated above. The main reason for it is that it enables the actual voltage applied to the meter tube grid to be less for a given meter reading than otherwise. If no voltage division were done, it would be necessary to apply a considerably higher H.T. voltage to the triode stages in switching by means of a voltage divider chain, which applies progressively smaller proportions of the total diode output to the metering circuit, as the ranges get higher. This scheme has the disadvantage of requiring a large number of accurately known resistors, especially in a circuit like this one, where the signal voltage divider would have to be duplicated in the circuit of V_3 and V_4 in order to keep the zero stability. The present scheme has the advantage of requiring only four accurately known high-value resistors, and obtains this at the expense of a limited upper end to the voltage range. When

(Continued on page 48.)

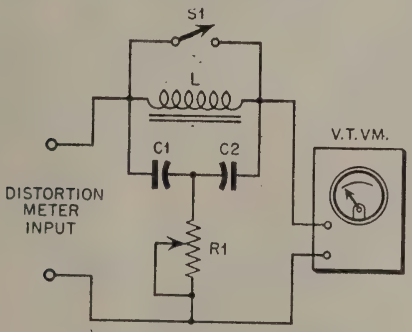
AUDIO FREQUENCY DISTORTION MEASUREMENTS

Part II—A Practical Distortion Analyser

By the Engineering Department, Aerovox Corporation

Part I of this series contained a discussion of the nature of audio frequency distortion and a survey of the methods employed in making quantitative distortion measurements on audio equipment. The present article details the design and construction of a simple and practical distortion analyser which is a very useful adjunct to any amplifier service shop or audio high fidelity experimenter's bench. The instrument is compact, easy to adjust and use, and costs little to build. Yet, the results obtained are sufficiently accurate to permit evaluation of the performance of most audio equipment and observation of the results of even minor design changes.

As was pointed out in Part I, the simplest form of distortion meter employs a null bridge to suppress the fundamental test frequency being amplified under test and a vacuum tube voltmeter to read the amplitude of



BASIC DISTORTION METER
FIG.1

linear, it is easy to express the total harmonic content thus indicated as a percentage of the amplifier output.

THE DISTORTION ANALYSER

The major shortcoming of the null bridge type of distortion meter, as it is usually employed, lies in its inability to identify the order of the harmonic content indicated. It reads *total* percentage of distortion and thus may only be classed as a distortion *meter*. To be considered a distortion *analyser*, the instrument should be capable of identifying each harmonic component present and indicating their relative amplitudes. Commercial distortion analysers which accomplish this are both complicated and costly. However, a simple system is available which is not appreciably more complicated than the common null bridge disctortion meter, but is capable of considerably better results. Its use is predicated upon the availability of a second audio oscillator.

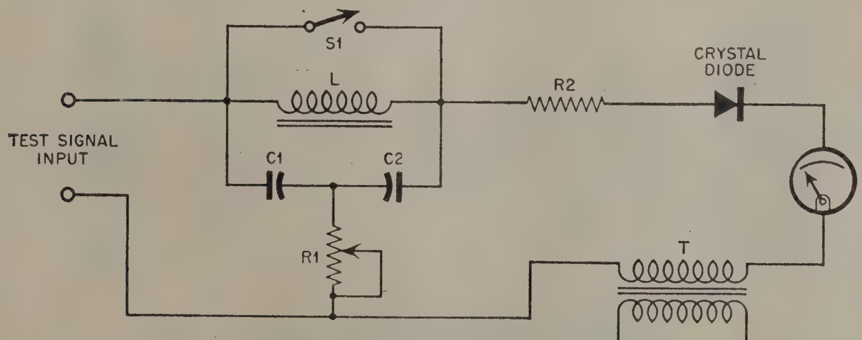
The circuit of a typical null bridge distortion meter is shown in Fig. 1. The components L, C_1, C_2, and R_1 constitute the null bridge network which suppresses the frequency at which L and the series combination of C_1 and C_2 are resonant, as given by:

(1)

$$\text{Null frequency (f)} = \frac{1.414}{2\pi\sqrt{LC}} \text{ cycles per sec.}$$

Where: L is the choke inductance in henries.
$C = C_1 = C_2$ is the capacitance of each unit in farads.

The circuit configuration will be recognized as the "bridge-T" type of network. The resistance (R_1) is used to adjust the null reading to minimum. If the circuit constants are chosen properly, and distributed capacitance is minimized, virtually zero transmission will occur at the null frequency. If the null circuit "Q" is high, the



DISTORTION METER MODIFIED
FOR HARMONIC ANALYSIS
FIG. 2

any signals which pass unattenuated through the null bridge. If the signal input to the amplifier is a pure sine wave of frequency equal to the null frequency of the bridge, the only signals indicated by the voltmeter will be the harmonics introduced by distortion in the amplifier being tested. If the response of the voltmeter is

null will be very sharp and nearby frequencies will be very slightly affected. The voltmeter is used to measure both total amplifier output and harmonic output by shunting out the bridge circuit with the switch (S_1) during the former measurement. A vacuum tube voltmeter may be employed, or as shown by Turner*, a

simple crystal diode voltmeter may be used with only a slight sacrifice in accuracy.

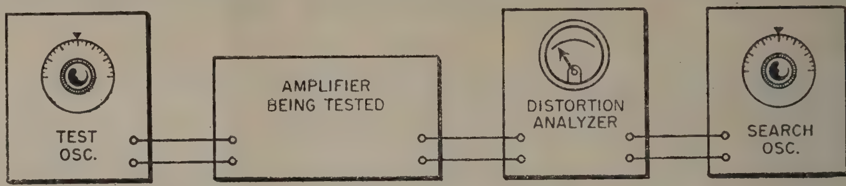
To convert the distortion meter of Fig. 1 to a distortion analyser, the modification shown in Fig. 2 is made. An audio transformer is added to permit the insertion of a sine wave signal from a second audio oscillator. This signal is used to identify individual harmonic components present in the bridge output by the beat method. To accomplish this, the second oscillator is swept through the frequency range containing the harmonics of the fundamental test signal. Fig. 3 of the block diagram of the complete test set up. Near the frequency of each harmonic present, a "beat" will be observed in the distortion meter reading. The amplitude of the beats are indicative of the relative magnitude of each harmonic component identified. Thus, a quantitative indication of harmonic content, as well as total harmonic percentage, is obtained.

As an example, suppose that the test frequency is 400 cycles and the distortion meter indicates a total harmonic distortion of 10 per cent. before the introduction of the "search" oscillator. If there is both second and third harmonic distortion, an amplitude beat will be observed when the second oscillator is swept through 800 and 1,200 cycles. If the second harmonic predominates, the beat at 800 cycles will be greater than the one at 1,200 c.p.s. in the same proportion. Knowing the total harmonic distortion, it is easy to evaluate the percentage of each harmonic component. The search oscillator frequency should be adjusted close enough to the harmonic irequency to give nearly zero beat, so that the meter needle can follow. The oscillator used for searching should be relatively free of harmonic output.

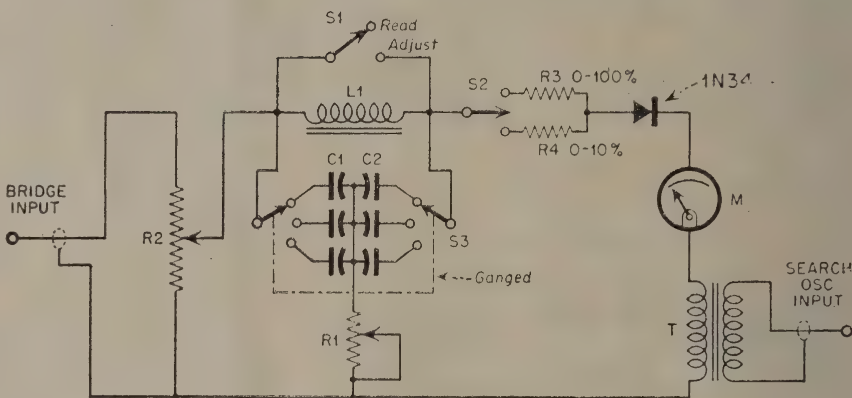
CONSTRUCTION DETAILS

The practical circuit diagram of the distortion analyser is given in Fig. 4. Since no vacuum tubes or power sources are required for its operation, the unit may be assembled in very compact form. A crackle-finish metal cabinet measuring 6 in. x 6 in. x 6 in. affords more than sufficient space to mount all components. No chassis is used; all parts are mounted on the front panel except the choke (L) and the audio transformer (T) which are supported by a sheet-metal shelf fastened to the back of the removable front panel by means of the shaft bushings of R_1, R_2, and S_2 (Fig. 4). The dimensions of this shelf and the approximate locations of the parts mounted on it are shown in Fig. 5. The suggested front panel lay-out is shown in Fig. 6.

To assure maximum versatility, three null bridge frequencies, 400, 1,000, and 5,000 cycles, are provided. These frequencies are selected by substituting the proper capacitance values for C_1 and C_2. Capacitor switching is done with a two-circuit, three-position wafer switch. If additional or alternative test frequencies are required, the

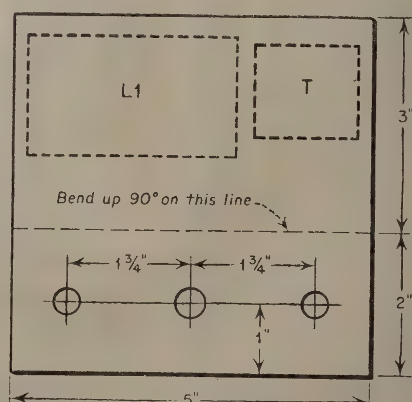


TEST SET-UP FOR DISTORTION MEASUREMENTS
FIG. 3



R1 - 1 megohm, carbon.
R2 - 1000 ohm, wire wound.
R3 - 30,000 ohms, ½ watt carbon.
R4 - 2000 ohms, ½ watt carbon. (Approx.) *See text.
S1, S2 - S.P.D.T. toggle switch.
S3 - 2 gang, 3 position wafer switch.
L1 - 8 hy. 150 ohm choke.
T - See text. M - 0-100 microamperes.
CRYSTAL - 1N34 or equivalent.
C1, C2 - 400 C.P.S. .04 µfd (Aerovox Type 489)
- 1000 C.P.S. .006 µfd (Aerovox Type 1089)
- 5000 C.P.S. .00025 µfd (Aerovox Type 1468)

PRACTICAL DISTORTION ANALYZER
FIG. 4



DETAILS OF SHELF
FIG. 5

WHAT "*Reception-Tested*" REALLY MEANS

Every Brimar valve has undergone *10* rigid and exacting factory tests to prove it one hundred per cent. efficient.

The process illustrated here positively identifies valves liable to crack during transit, handling, or long working life.

After preliminary tests, every valve is immersed in boiling water and immediately allowed to fall on to a hard, cold surface. This "thermal shock test" ensures that serious glass strains will at once reveal themselves as cracks and the defective valves are rejected.

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necessary capacitor values may be computed from:
(2)

$$C_1 = C_2 = \frac{1}{158f^2} \text{ farads (for 8 henry choke)}$$

Where: f is the desired null frequency.

For most routine amplifier testing, the three frequencies for which values are given in Fig. 4 will be sufficient.

For effective fundamental frequency rejection with low harmonic frequency attenuation, the "Q" of the null bridge components must be high. Best quality components should be used for the resonant circuit comprising C_1, C_2 and L. The choice of the choke is important since the resistance as well as the inductance of this unit is critical. The resistance of the choke will adversely affect the "Q" of the null circuit if too high.

Some selection of capacitors may be necessary to arrive at any given test frequency, although for most practical purposes it is not necessary to measure distortion at exactly the frequencies specified.

The null resistor (R_1) is a variable one megohm potentiometer mounted on the front panel and provided with a small knob. This control is used to adjust the null response to minimum at each of the test frequencies. The setting of R_1 usually remains fixed for any given frequency.

Th crystal diode voltmeter uses a 1N34 or any of the germanium crystals as a rectifier. It gives a response that is approximately linear with input voltage if a high sensitivity meter is used. A 0–100 microampere meter is ideal, since the scale calibration can be used to indicate distortion percentage directly. Otherwise, any meter requiring less than about 250 microamperes for full scale deflection may be employed. Above this current, the average crystal diode characteristic departs markedly from linearity.

Two meter ranges are provided to allow more accurate reading of distortion percentages. These ranges, 0–100 per cent and 0–10 per cent., are selected by switching meter multiplier resistors R_3 and R_4 by means of a toggle switch (S_2). The multiplier resistor for the 0–10 per cent. scale is selected to give full scale deflection at 1/10th the RMS input voltage required to give full scale reading on the 0–100 per cent. range.

The audio transformer (T) may be almost any unit of good quality which the experimenter might have available. The characteristics are not critical, since this transformer is used merely to introduce a small audio voltage from the search oscillator into the voltmeter circuit. A good 3 : 1 interstage audio transformer will usually be found satisfactory.

The audio input cable to the bridge circuit, as well as the external lead to the search oscillator, are run through holes in the left hand side of the metal cabinet and wired permanently to the circuit. These leads are of standard single-conductor shielded audio cable and are fitted with alligator clips at the input ends. The cabinet holes should be fitted with rubber grommets.

USING THE DISTORTION ANALYSER

The use of the instrument is relatively simple. After the construction has been completed, the operation of the null bridge circuit is tested at each of the test frequencies. To do this, the bridge input cable is connected directly to the output terminals of the test oscillator. With the toggle switch S_1 in the "Adjust" position and the test oscillator and frequency selector switch set at the proper test frequency, the output of the test oscillator and the gain control (R_2) are adjusted to give full scale deflection of the distortion meter. Then, when S_1 is thrown to the "Read" position, the meter reading should drop to a very low value. To minimize the reading, the null resistor (R_1) and the test oscillator frequency must be varied simultaneously. If the null bridge is functioning properly, the adjusted null at some frequency near the desired test frequency will be quite sharp and the meter reading will be very nearly zero.

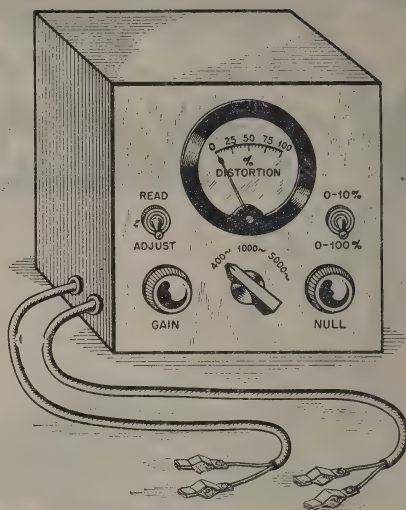


FIG. 6

If an incomplete null is obtained, the bridge components are faulty or the test oscillator has some harmonic

(Concluded on Page 48.)

THE SHORT-WAVE MINIATURE THREE

PART II: MAKING THE COILS AND OPERATING THE SET

In the first instalment of this article, which appeared in the March 1951 issue of *Radio and Electronics*, the circuit and construction of the set was described, and photographs of the prototype were featured so that builders would be able to duplicate the original layout as closely as possible. In this, the final instalment, details of the coils are given, and this is followed by some tips on operating the set so as to get the best results out of it.

MAKING THE COILS

The set covers the whole of the normal short-wave range of 3 to 30 mc/sec. To do this, three sets of two coils per set are needed, making six coils in all. They are not difficult to make, being wound on commercially available coil formers with enamelled wire that is in all cases thick enough to be quite easy to handle. The numbers of turns on all winds are given in the table below:

	L_1	L_2	L_3	L_4	Tap on L_3
RANGE A					
No. of Turns	5	26	26	$3\frac{1}{2}$	$3\frac{1}{2}$
RANGE B					
No. of Turns	$4\frac{1}{2}$	13	13	$2\frac{1}{2}$	$2\frac{1}{2}$
RANGE C					
No. of Turns	$2\frac{1}{2}$	$5\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$

NOTE.—L_2 and L_3 for Range A are wound with 30-gauge enamelled wire. For Ranges B and C, these windings are of 20-gauge. For all ranges, windings L_1 and L_4 are of 30-gauge wire.

All coils are wound on ribbed formers, $1\frac{1}{4}$ in. in diameter. These formers are provided with bases carrying the pins with which the whole is plugged into the valve-socket holders, and which carry the electrical connections from the coils. The bases are held to the base of the former by a single screw, threaded into the bakelite, and so can be removed entirely while the windings are being put on. To hold the windings on the former, small holes are bored in it with a sharp instrument, such as scriber point, or a bradawl, with the business end filed down to a width of about one thirty-second of an inch. To commence a winding, one hole is bored in the former, close up to one of the ribs, and a short length of the wire threaded through, on to the inside of the former. It is then taken down to the bottom of the former, where there is a flange, with several small holes already provided. The wire is taken round the flange, to the outside of the former, and then passed down through the nearest hole, where it is left projecting. The wire can then be pulled taut without fear of its coming adrift. The required number of turns is now wound on, which brings the winding near the bottom of the former, and wire is held while a further hole is bored in the former. The wire is cut from the reel, leaving several inches to spare, and threaded through the newly-made hole, just as at the start of the winding. It is then brought out at the bottom of the former, as before, and anchored in a further hole in the flange. All the coils are space-wound. That is, L_2 and L_3 are wound with the turns spaced from each other by a distance equal to the diameter of the wire. This is easily accomplished in the following way. After the wire has been anchored for the start of the winding, a second piece of the same wire is temporarily anchored by passing it through the same hole as the main wire, but this time, taking it out through the top of the former, and simply bending it over. We now have two wires coming out of the starting hole, and these are wound on, side by side, so that the whole makes a solid winding, with the turns tightly pressed up to each other. On coming to the end of the winding, the additional wire is released, and springs away from the former, leaving the main wire wound on, very accurately spaced. Since bakelite formers are slippery, care is needed to ensure that after the spacing wire has been released, the turns of the main winding do not slip, or the spacing will be lost, and it will be necessary to start again.

ADDING THE SMALL WINDINGS

Of course, the main windings are L_2 and L_3, which are the tuning coils, and these should be put on first. Then the small windings can be added. In the case of L_1, the following procedure will do the trick. A small hole is bored in the former, five turns up from the bottom of the main winding. It will not be possible to do this without disturbing the spacing of the lower turns of the coil a little, but as long as its ends are secure, this does not matter. L_1 is then started from the bottom end, by reeving it through one of the holes provided in the flange. The turns are then wound on, in between the turns of L_2, until the ending hole, which has just been made, is reached. It is then passed through this hole, and taken down and anchored, as before. Since both windings are of the same wire, the turns will bed together closely, and will automatically correct the spacing that was displaced while boring the finishing hole.

On the other coil, L_4 is put on in a similar manner, but not until the tap has been added to L_3. The best way to do this is to wind L_3 completely for a start, and then bore a hole at the appropriate spot on the former. Just opposite the hole, the wire of L_3 is carefully scraped to remove the enamel, and the bare surface is tinned with solder as quickly as possible, so that the wire will not stretch with the heat and become slack. Then a short piece of wire is anchored to one of the flange holes, and taken up inside the former, and out through the hole drilled for it. A piece of the wire is bared and tinned, and soldered to the tinned spot on the main coil, and the tapping is completed. L_4 is then put on exactly as for L_1, except that in this case, the finishing hole is made about $\frac{1}{8}$ in. from the hole for the tapping wire, and it is necessary to see that inside the former, the wires from the tap and from L_4 do not touch. If they did, the filament of V_2 would be short-circuited, and so would the A battery when connected up.

The coil for Range A will be the most difficult to make, because all windings are of the same relatively thin wire, but with the others, there will be plenty of room between the wires of the tuning coil to bore the necessary holes, and to wind the thin wire.

CONNECTIONS TO THE COIL SOCKETS

Readers will probably have noticed that we have not shown any schedule for connecting the various coil windings to the pins of the coil formers, and so to the coil sockets on the set itself. This has been done on purpose, because there is no particular virtue in using any pins for a particular winding, and builders may please themselves what pins are used for what. The best plan, to avoid possible confusion, is to mark on the circuit diagram the socket pins that it is intended to use. The best sockets to use are of the Amphenol type, and these always have the pin connectors numbered. These numbers should be inserted in the circuit diagram in accordance with the way the underneath of the set has been wired. Then, when it comes to making the coils, the windings

can be terminated on the right pins to make the circuit correct when the coils are plugged in. If the top (grid end) of L_2 is connected to pin No. 4 on the socket when the coil is plugged in, then pin No. 4 must be connected to the grid of V_1 and to the stator of the gang condenser when the set is wired—or vice versa. Needless to say, all corresponding coils must be made with the same pin numbers connected to corresponding ends of the windings.

PUTTING THE SET INTO OPERATION

If the wiring has been done without any mistakes, and if the coils have been made properly, according to specifications, then the set should go at first switching on. However, it is a very good plan to do some checking before connecting any of the batteries to the set. Go over the circuit carefully, and see that none of the connections have been accidentally misplaced, or omitted altogether. When satisfied that the wiring is correct, give the coils a close examination and make sure that the windings terminate on the right pins on the former. For example, if the aerial end of the aerial coil has been taken to pin No. 1 on the coil, make sure that No. 1 connection on the socket actually goes to the aerial, and so on, for all the connections. Choose one set of coils for this check, and until the set works with this set, ignore the others altogether. The best set to use for initial testing is Range A, for it will be easier to get it going on this range.

If you are satisfied that all wiring, and coil connections are correct, it is time to connect the A battery. Turn it on, and then examine the valves very carefully—preferably in the dark. If the filaments are alight, it will just be possible to see it glowing a faint red in the dark, or in subdued light. In this way we can check that all three filaments are running. If one does not light, then re-check the filament wiring, and if this is O.K., the valve would be suspected. To test it, connect one tag of the headphones to the A battery, one filament pin of the valve to the other A battery terminal, and complete the circuit by touching the remaining phone tip to the other filament pin. Needless to say, if there is continuity, a loud click will be heard in the phones. If not, the filament is open, and the valve useless. Of course, for the test, the valve is removed from its socket, and the battery disconnected from the set.

When the filaments are all alight, the negative end of the B battery can be connected, the phones plugged in, and finally, the postive terminal of the battery connected. This also should give quite a loud click in the phones, as V_3 starts to pass plate current. The next thing to do is to test for oscillation. The aerial is left disconnected, and with the condenser gang set at about mid-scale, the reaction control, R_4, is slowly advanced, and a sharp watch is kept for the appearance in the phones of a rushing noise, which should appear as the reaction control is rotated. *Slow* operation of the control is essential, because it is easy to go past the right point, after which the noise disappears again. If this noise is found, as it should be, then all is well, and we can proceed to see whether it is obtained, as it should be, at all possible settings of the tuning dial. The position of the reaction control will be slightly different, according to where the tuning dial is set, but if all is well, there will be little change in its setting as the tuning dial is moved from one end to the other. If it is found that at the low-frequency end of the tuning dial, no setting of R_4 enables the rushing sound to be heard, it means that L_4, and a few turns of L_3 below the tap, should be squeezed up a little towards the rest of L_3. Only a very slight adjustment in this way can produce a large effect, and such adjustment may be all that is needed to make the reaction control work properly even if no oscillation can be found at any point on the dial for a start.

With the rushing sound, which indicates that the detector is oscillating gently, it will now be possible to connect the aerial to the set. Then by turning the main dial, signals should be heard as whistles, which are tuned over in turn as the dial is rotated. Pick a loud one, ignoring the very weak ones that may be heard, and set the dial as close as possible to the spot where the whistle descends to a low growl. Then, *very carefully,* back off the reaction control until the whistle disappears. If the signal is speech or music, then this will now be heard. If the signal was morse code, then the dots and dashes would already have been heard as interruptions to the whistle. A station transmitting speech or music will be heard as a steady whistle, with perhaps just a suggestion of the music present. This is really all there is to tuning the set. The important thing to know is that the set is most sensitive when it is *just not oscillating,* and for hearing weak signals it will have to be tuned in very carefully. The best results will be had if, after backing off the reaction control to remove the whistle, the tuning is rocked very carefuly to see if the signal cannot be made just a little louder. However, with this set, re-tuning in this way will only need to be very slight, if any, since the reaction control has very little effect on the tuning of the signal.

TUBE DATA: Some Lesser-known but Useful Valve Types—Part III

THE 954 ACORN PENTODE

The 954 is one of the two chief companion tubes to the 955 triode, whose characteristics were featured in this page last month. It is a pentode, with a 150 ma. heater operating at 6.3 volts, and it has a sharp cut-off characteristic. It is particularly suited to use as an R.F. amplifier, and may also be used as a mixed in super-heterodyne circuits, or as a biased detector in "straight" sets in the V.H.F. and U.H.F. region. In the data sheets reproduced below, information is given for working the 954 in both these ways. As a mixer, it can be used under the same condition as specified for use as a detector, with the oscillator voltage applied to the control grid, the screen, or the suppressor. In the latter two cases, a considerable oscillator voltage is needed, but with control grid injection, only a very small oscillator voltage is required. It will often be sufficient in this case to place the oscillator tank coil within two or three inches of the tuned grid coil, or, if it is preferred to shield the oscillator from the mixer as completely as possible, the coupling can be effected by joining the oscillator grid to the mixer grid through a very small condenser of not more than 5 $\mu\mu f$.

By modern standards, the 954 has a rather low mutual conductance, but its low grid damping will in most cases enable it to give a considerably greater stage gain at frequencies over 50 mc/sec. than a conventional tube of much higher mutual conductance.

It will be noted that the valve can also be used as an audio amplifier stage, with resistance-capacity coupling. It would, of course, not normally be used for this purpose, but with its present low price it may be worth while to do so in order to reduce the number of tube types contained in a receiver.

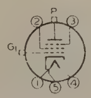
The 954 and 955 will be found excellent tubes for frequencies between 50 and 400 mc/sec., not only in conventional circuits, but also in applications used less often, such as regenerative detectors and super-regenerative detectors. In the latter application particularly, they

DETECTOR AMPLIFIER PENTODE

ACORN TYPE

Especially for wavelengths as short as 0.7 meter

Heater	Coated Unipotential Cathode	
Voltage	6.3	a-c or d-c volts
Current	0.15	amp.
Direct Interelectrode Capacitances:		
Grid to Plate●	0.007 max.	μμf
Input	3.4	μμf
Output	3.0	μμf
Overall Length		1-11/16" ± 3/16"
Overall Diameter		1-3/32" ± 1/16"
Bulb	See Outline in GENERAL SECTION	T-4½
End Terminals		Two
Base		Small Radial 5-Pin
Pin 1 – Heater		Pin 5 – Cathode
Pin 2 – Grid No.2		P – Plate
Pin 3 – Grid No.3		G_1 – Grid No.1
Pin 4 – Heater		
RCA Socket		Stock No.9925
RCA Grid & Plate Clips		Stock No.9939
Mounting Position		Any



P is on Long Part of Bulb: Top
G_1 is on Short Part of Bulb: Bottom

BOTTOM VIEW (5BB)

Maximum and Minimum Ratings Are Design-Center Values

A-F AMPLIFIER

D-C Plate Voltage		250 max.	volts
D-C Screen (Grid No.2) Voltage		100 max.	volts
D-C Grid (No.1) Voltage		−3 min.	volts
Plate Dissipation		0.5 max.	watt
Screen Dissipation		0.1 max.	watt
D-C Heater-Cathode Potential		80 max.	volts
Characteristics— Class A_1 Amplifier:			
D-C Plate Voltage	90	250	volts
Suppressor (Grid No.3)	Connected to cathode at socket		
D-C Screen Voltage	90	100	volts
D-C Grid Voltage■	−3	−3	volts
Plate Resistance	1.0	Greater than 1.0	megohm
Transconductance	1100	1400	μmhos
D-C Plate Current	1.2	2.0	ma.
D-C Screen Current	0.5	0.7	ma.
Typical Operation with Resistance-Coupling:			
Plate-Supply Voltage○		250	volts
Suppressor	Connected to cathode at socket		
D-C Screen Voltage		50	volts
D-C Grid Voltage■		−2.1	volts
Load Resistance		0.25	megohm
D-C Plate Current		0.5	ma.
Second Harmonic Distortion		5	%
Voltage Output		40 to 50 RMS	volts
Voltage Gain		100 approx.	

(continued from preceding page)

DETECTOR

D-C Plate Voltage	250 max.	volts
D-C Screen (Grid No.2) Voltage	100 max.	volts
D-C Heater-Cathode Potential	80 max.	volts
Typical Operation— Biased Detector:		
Plate-Supply Voltage○	250	volts
Suppressor (Grid No.3)	Connected to cathode at socket	
D-C Screen Voltage	100	volts
D-C Grid (No.1) Voltage	−6 approx.	volts
Load Resistance	0.25	megohm
D-C Plate Current	Adjusted to 0.1 ma. with no input signal	
Cathode Resistor	20000 to 50000	ohms

● With shield baffle.

■ Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.5 megohm with fixed bias, or 1.0 megohm with cathode bias.

○ This is a plate-supply voltage value. The voltage effective at the plate will be plate-supply voltage minus the voltage drop in load caused by the plate current.

R-f grounding by means of condensers placed close to the tube terminals is required if the full capabilities of the 954 for ultra-high-frequency uses are to be obtained. It is important in the cases of the plate and control-grid circuits that separate r-f grounding returns be made to a common point in order to avoid r-f inter-action through common return circuits. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the return or supply lead for the grid, the screen, the suppressor, the plate, and the heater.

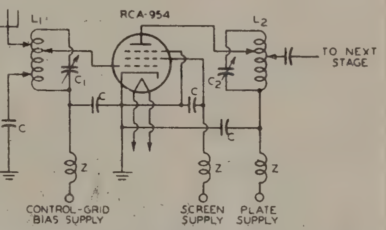
TYPICAL R-F AMPLIFIER CIRCUIT

For ultra-high frequencies, coils L1 and L2 may be tapped at suitable points determined by test to reduce effect of tube loading on circuit impedances.

Because electronic plate loading is not serious in a pentode, the use of coil L2 with tapped plate connection may not be necessary to give satisfactory results.

The condensers should all be of high quality and be designed for ultra-high frequency operation.

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.



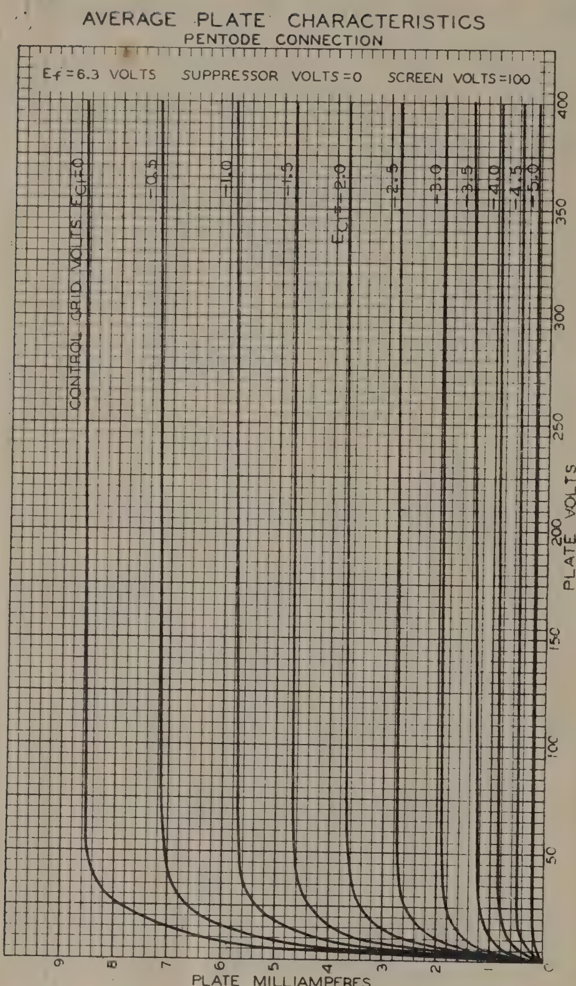
92CM-4386R2

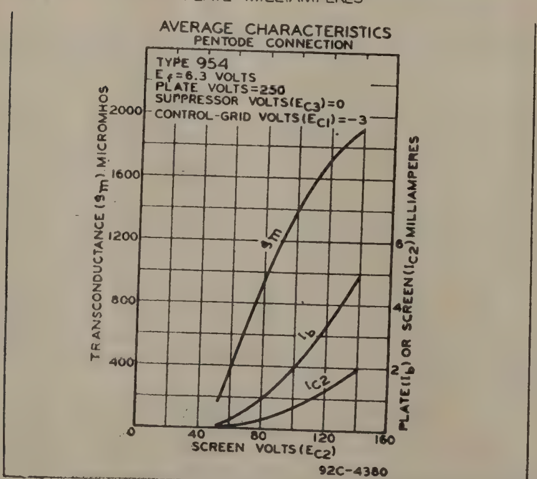
WAVE-LENGTH RANGE		2.75 TO 5.3 METERS APPROX.	1 TO 3 METERS APPROX.	0.8 METER APPROX.
L_1, L_2	TURNS	10	4	5
	WIRE	No.16 B.C.*	No.16 B.C.*	No.30 B.C.*
	OUTSIDE DIA.	3/8"	3/8"	1/8"
	LENGTH	3/4"	5/16"	1/8"
C_1, C_2 (VARIABLE)		3 TO 25 μμf	3 TO 25 μμf	3 TO 4 μμf
C		100 TO 500 μμf	100 TO 500 μμf	100 TO 500 μμf
Z	TURNS	15	15	15
	WIRE	No.30	No.30	No.30
	OUTSIDE DIA.	1/4"	1/4"	1/4"
	WINDING	S.L.□	S.L.□	S.L.□

*B.C. = BARE COPPER □S.L. = SINGLE LAYER

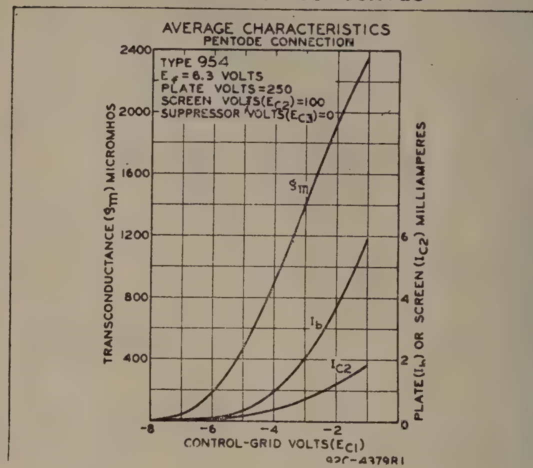
← Indicates a change. NOTE: THE ABOVE DATA ARE NECESSARILY APPROXIMATE

will be found to give remarkably good performance compared with larger tubes.





CHARACTERISTICS CURVES



An Easily Constructed Instrument For Measuring R.F. Resistance And Other Important Quantities—Part II

CONSTRUCTION

The instrument is very easy to construct, and, as can be seen from the photograph on page 6 of the last issue, the whole circuit is built on the steel panel, and the leads are cabled and taken off to the batteries, which are housed inside a box, 11 in. x $7\frac{1}{2}$ in. x $6\frac{1}{2}$ in. The panel fits over, and forms the lid for one of the 11 in. x $7\frac{1}{2}$ in. sides of the box.

The valve is mounted in an Amphenol socket, which is set into a circular base, of the kind used for setting such sockets into a chassis. In this case, the socket is mounted with the lugs inside the base, which is then screwed to the panel, as shown in the photograph. A low-loss socket needs to be used, because the plate connection comes out through the base of the tube, and this pin is connected to the "high" side of the circuit under test. This arrangement gives a very short lead to the ceramic feed-through insulator which is used for connecting the test circuit to the dynatron, and this is of assistance at high frequencies, where short leads and low losses are essential.

The three controls are mounted in a row along the bottom edge of the chassis, and are provided with large knobs to make accurate adjustment easy. Apart from the three potentiometers, four fixed resistors, and the plate and screen bypass condensers, the only parts are the valve itself and the three meters, so that all the parts can be mounted using the terminals of the meters and the switch as tie points. The grid stopper resistor is mounted in the grid lead itself, right at the grid cap of the valve. Please note that there is only one earth on the whole instrument—at the earthed feed-through, very close to the valve socket. In the original, the whole circuit was built, completely insulated from the panels, and then a wire was soldered from the one input terminal to the panel. As was pointed out earlier, as long as the bypassing from plate and screen to the cathode is inserted with as little lead length as possible, the whole of the rest of the circuit is purely a D.C. one, so that the exact lay-out of parts, and the way in which the wiring is run, is of little or no consequence. For this reason, builders may please themselves just how they construct the instrument, as long as the two leads that carry R.F., and the bypass condenser leads, are made as short as possible.

CHOOSING A TUBE

We have not yet said anything about how to come by a valve for the dynatron. In the circuit, this has been shown as a 224, and this is quite correct. It is certainly true that new valves of this type can no longer be had, and it is equally true that if they were available, the chances are that they would not be suitable for the purpose in hand. The trouble is that only the very old screen-grid tubes show the best dynatron characteristics, because the secondary emission phenomenon which makes the dynatron oscillator possible was looked upon as a disadvantage when screen grid tubes were first produced, and steps were taken to eliminate the secondary emission. As a result, the 24A, an improved version of the 24 or 224, was produced, and this had the plate specially treated to make the secondary emission as small as possible. The 24A, therefore, is not the tube to use in this arrangement. There are still to be found, more particularly in the junk boxes of dealers and service shops, some of the old 224 tubes, which can be used, even if their emission is somewhat on the low side. The one used in the prototype was one of Arcturus manufacture, with the blue glass envelope, and proved quite satisfactory for the purpose. If one is lucky enough to acquire more than one of the right sort of tube, there then arises the problem of finding out which is the best of them to use. This can be done quite easily, in the following way. A tuned circuit—say a broadcast coil with about 200 $\mu\mu$f. connected across it, is connected to the test terminals, and a voltmeter is connected between the cathode and the moving contact of the 500-ohm potentiometer. The grid bias is decreased until the circuit just oscillates, and a reading of the grid bias voltage is made on the temporarily connected meter. Then the next tube is plugged in and the process repeated. The tube with the best dynatron characteristics is the one which oscillates with the *highest* value of grid bias.

The reason for this is that the greater the negative mutual conductance, the higher can be the bias, while still allowance a given circuit to oscillate.

USING THE INSTRUMENT

The simplest use to which the instrument can be put is that of measuring the dynamic impedance of a tuned circuit. When it has been completed, some trial measurements should be made, to see that it is working satisfactorily. Apart from the meter itself, it is necessary to have some means whereby one can ascertain when the circuit starts to oscillate. In many cases this can be a sensitive radio receiver, or, if one is available, a beat frequency meter. For those who have no more elaborate equipment, the best solution is to make up a simple regenerative detector circuit, using a triode, with plug-in coils to cover the frequency range in which you are interested. This can incluude the usual I.F. band round about 455 kc/sec., since an old I.F. transformer can easily be modified to act as a plug-in coil for such a detector. A short piece of stiff wire, to act as an aerial, can be connected to the detector circuit, and placed within a couple of inches or so of the circuit under test in the resistance meter. Then, the latter is turned on, and the grid bias potentiometer is turned to the position which gives minimum bias on the 224. At this, the circuit is bound to be oscillating, so a search is made in the expected frequency range with the regenerative detector, until the signal is picked up. When found, the 224 bias control is backed off, and then advanced slowly until the circuit just goes into oscillation. In judging the onset of oscillation, the best plan is to set the detector so that when the dynatron is oscillating, a beat note of about 1000 c/sec. is heard. Then, when the bias control is operated, the start of oscillation will be accurately indicated by a sudden appearance of the 1000 cycle note. It will then be found a simple matter to set the dynatron bias very accurately to the point where the circuit is just hovering between the non-oscillating and oscillating conditions.

When this condition has been reached, it is necessary to measure the negative resistance. This is done as follows. The test coil is removed, and replaced by a short thick piece of wire as a shorting bar. Next, the balancing potentiometer is turned until only about one scale division of deflection is left on the 100 μamp meter. The switch is then held down, to remove the meter shunt while the additional plate voltage cotrol is manipulated. With the switch held down, plate voltage is added by means of the potentiometer until the meter shows a drop of 10 μamps. The switch is then released, and the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additional H.T. voltage is read from the voltmeter. If, as recommended, the meter is scaled to read 5 volts at full scale deflection, the resultant negative resistance can be read off as hunderds of thousands of ohms. This figure, as explained above, is the dynamic impedance of the test circuit, commonly written as R_d.

How, then, is the circuit Q found? The important formula which connects R_d with Q is as follows:—

$$R_d = 2\pi fLQ$$

where f is the frequency in cycles per second.
L is the coil's inductance in Henries, and
Q is the Q of the tuned circuit.

From this simple formula, it can be seen that if R_d, f, and L are known, then Q can be found. However, for most purposes it will be unnecessary to go to all the trouble of finding Q, since the most commonly required answer is to find how well a given coil should perform in an actual circuit, and the value of R_d does this much much directly than the value of Q. For instance, if one has a batch of coils, and it is suspected that some of them are not as good as they should be, the value of R_d is all that is required, not only to sort them out in order of goodness, but in order of the *actual gain* to the expected use. The only assumption here is that when tested, all coils are tuned to the same frequency. This can easily be arranged by tested the coils in a tuned circuit made up of the coil itself, and a good low-loss variable condenser. The oscillation indicator—the regenerative detector whose use was described earlier—can also be used to set them to the desired frequency so that it is quite unnecessary to know the *exact* frequency. All that is needed is to know that this is close to the required operating frequency, and that all coils tested are tested at the *same* frequency.

OTHER MEASUREMENTS

Now that we have a means of measuring R_d, which is only another name for the parallel R.F. resistance at resonance, we are in a position to measure the R.F. resistance of resistors, to measure the R.F. shunt resistance of condensers, and many other things. In fact there are so many measurements that can be make with the aid of the resistance meter that a separate article will be necessary if they are all to be described in detail. However, as an interesting illustration of what can be done, let us take the case of a condenser—say a fixed tuning condenser from a permeability-tuned I.F. transformer that is suspected by being leaky. What we want to know is how leaky the condenser is, and whether it is bad enough to have an adverse effect on the gain of a transformer in which it may be used. The actual shunt resistance *at R.F.* represented by the leaky condenser can be measured as follows:

A suitable coil is taken, such as a winding from an I.F. transformer, and together with our low-loss variable condenser is made into a tuned circuit and connected to the dynatron. The R_d of the combination is measured in the ordinary way, and the figure noted. Then, the suspected condenser is connected across the coil, and capacity is removed from the variable until the oscillation frequency is the same as before. Then the R_d is measured once more. If the added condenser is a good one, the two figures for R_d will be the same. But if the condenser is leaky, then the R_d will be reduced, and from the two figures obtained, we can easily calculate the equivalent shunt resistance of the condenser. For example, if the original R_d was 300k., and the R_d after connecting the condenser was 250k., we proceed as follows:—

The value of two resistances, A and B, in parallel, is given by AB ÷ (A + B), so that we can write

$$250 = \frac{300x}{(300 + x)}$$

or, $300x = 250x + 75{,}000$

thus, $50x = 75{,}000$, and

$x = 1{,}500$

But we have worked our sum in thousands of ohms, instead of in ohms, just so as to avoid a large number of zeros in the working, so that the answer is 1500k., or 1.5 megohms.

The condenser is therefore exactly equivalent to a perfect one, shunted by a resistor of 1.5 megohms. This is not very good, as the losses in a condenser like this should be so low as to make no noticeable difference to the R_d. Incidentally, this shows how sensitive the method is, and also, that a condenser which would be perfectly good if used as a bypass condenser at low voltages, would not necessarily be good enough to use as a tuning condenser.

As can be seen, the method outlined above could not be applied to finding the actual R.F. resistance of low-value resistors, for when connected in parallel with the test circuit, they would reduce the R_d so much that the dynatron would no longer be able to make it oscillate. However, low resistances can be measured, by putting the resistance in *series* with the coil instead of in parallel with it, and then using a different calculation. This, and the other things that can be done with the dynatron will have to be left for a later article, but in the meantime, those interested can rest assured that the dynatron measuring instrument is well worth having on its own account, and even more so when a little additional equipment, such as a capacity bridge, can be built or purchased, so that a very wide range of R.F. measurements become possible.

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Our stocks have lately been exhausted but further supplies have now come to hand. We very much regret to advise subscribers that printer's charges for further supplies have so risen that we have to raise our prices too, but so as to keep the cost of single binders within reason we have been forced to discontinue discounts on quantity copies.

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The PHILIPS Experimenter

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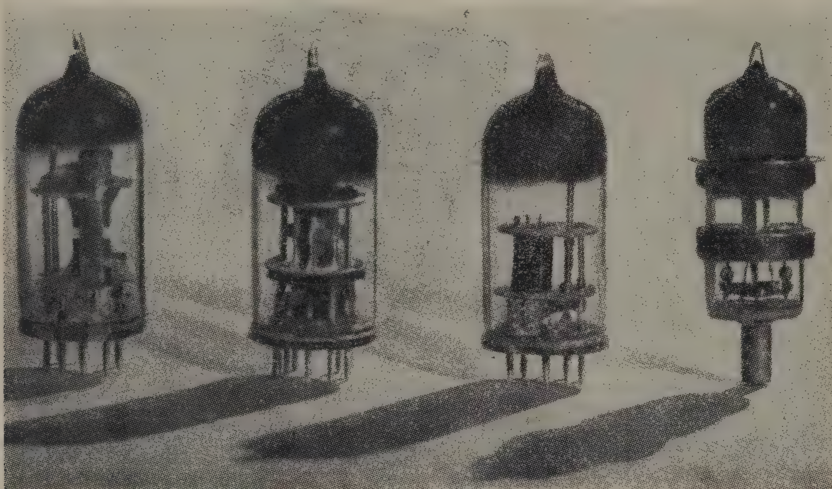
No. 43: Some Philips Tubes for U.H.F. Communication and Measuring Equipment



Photograph showing the construction of the four Tubes. On the right is the EC55.

INTRODUCTION

Modern electronic technique has given rise to new and important applications in radio communication, and in other electronic fields, and the development of new types of valves, such as the klystron and magnetron, has enabled higher and higher portions of the radio spectrum to be utilized, as never before. But in spite of the revolutionary nature of these developments, and the way in which they have, quite rightly, attracted so much attention among technical men, much skill and ingenuity has been expended in another less spectacular, yet no less important direction.

We refer to the improvement of what may be termed "conventional" valves in such a way that they can be used efficiently at progressively higher frequencies. At one stage, it was thought that attempts of this nature were doomed to suffer from the law of diminishing returns, but Philips designers have brought so much skill to bear that we are now treated to the once unbelievable spectacle of tubes of conventional construction, which will amplify and oscillate at frequencies as high as 1000 megacycles per second.

The importance of such tubes lies in the fact that they enable well-known circuit techniques to be extended further into the U.H.F. region, so that they simplify equipment, reduce its cost, and improve its reliability. This issue of the Experimenter deals wtih four new tubes, all of them triodes, bearing the type designations DC80, EC80, EC81, and EC55. Of these, the first three are conventional in that they use the ordinary plug-in type of valve socket, while the last is of the disc-seal, or "lighthouse" variety, specially designed physically to fit easily into co-axial line circuitry.

BRIEF DESCRIPTIONS

The Philips DC80 is a directly-heated triode using a standard Noval base. It is intended for dry battery operation, and can be used as an oscillator or super-regenerative detector up to 750 mc/sec., or as a superheterodyne mixer up to 500 mc/sec.

The EC80, also Noval based, has 6.3 volt heater-cathode construction, and can be used as an R.F. amplifier or mixer up to 500 mc/sec. It has a high amplification factor and a very small plate-cathode capacity, and is specially suited to application as a grounded-grid amplifier.

The EC81 is also a 6.3-volt heater-cathode valve, on a Noval base, and is designed more particularly as an oscillator for frequencies up to 1500 mc/sec. It will, of course, function as a super-regenerative detector up to the same frequency.

The EC55 disc-seal triode can be used as a receiving R.F. amplifier up to 1000 mc/sec., as a transmitting amplifier up to 3000 mc/sec., as a mixer up to 1000 mc/sec., and as an oscillator up to 3000 mc/sec.

DESIGN PRINCIPLES UTILIZED

There are three groups of phenomena which each play a part in limiting the maximum frequency at which valves will work. They are:

(1) The effects due to the time taken for the electrons to travel from the cathode to the plate inside the tube. These become troublesome, in a particular valve, when the time of travel is no longer short compared with the duration of one cycle of radio frequency. The transit time effect decreases the mutual conductance of the valve, damps the input circuit, and reduces the signal-to-noise ratio.

(2) Undesired couplings brought about by the capacities, inductances, and mutual inductances of the valve electrodes and their leads. These undesired circuit elements are negligible at lower frequencies, where the capacities are very small compared with the normal circuit capacities, and the inductances are also small compared with the circuital inductances. At and near the limiting frequency of a valve, these reactances can determine a maximum frequency themselves, irrespective of other factors, and so are required to be as small as possible in a valve designed for U.H.F. operation.

(3) The third group comprises losses such as dielectric losses in the glass of the valve, and resistive losses in the valve elements themselves, and in the leads connecting them to thhe outside circuit. At U.H.F., the losses in the electrodes themselves predominate.

TRANSIT TIME

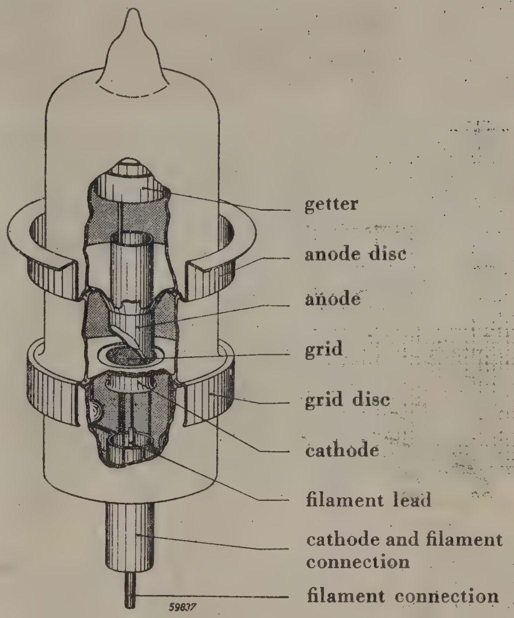
The most obvious way in which transit time can be minimized is by reducing the clearance between the electrodes. This is especially importance in the case of the grid-cathode spacing, because here the velocity of the electrons is low, and it is therefore more necessary to have a short distance if the travel time is to be reduced. Unfortunately, however, bringing the grid closer to the cathode increases the capacity between the two electrodes, but it also increases the mutual conductance of the valve, and it has been proved that in spite of the adverse effect of the increasing capacity, there is a net improvement in high frequency properties. For this reason, in all four of the valves under consideration, the grid-cathode spacing has been decreased to a minimum, consistent with mechanical reliability and increased difficulty of manufacture.

COUPLING EFFECTS AND LOSSES

One way of attacking the problems of both ohmic losses and undesired reactances, is to make the connections between the valve elements and the pins, as well as the pins themselves, as short as possible, enabling very short connections to be made to the external circuit. In the DC80, EC80, and EC81, this has been achieved by using the now well-known Philips sintered glass "button" base, with its short, thick connecting leads, and mounting the electrode structure directly on these leads. The connecting pins, and the nickel connecting straps between them and the electrodes, are both plated either with silver or copper in order to reduce the ohmic resistance; at 300 mc/sec., this alone reduces the lead resistances to a tenth of their previous value. In the EC55, however, there are no connecting pins at all, as the electrodes themselves are extended into discs, sealed into the glass envelope right round its circumference, thus providing large volume and contact area, which both effectively reduce the resistance of the connections. In the disc-seal tube, too, much shorter inter-electrode spaces are made possible by the use of parallel-plane electrodes, which can be made more rigid than conventional electrodes, thus allowing closer spacing still, without danger of mechanical troubles, such as short-circuiting between the electrodes owing to sagging of the grid, for example, when the tube becomes hot in use. The external form of disc-seal tubes is such that they can be used with concentric line circuits, when they actually become part of the circuits, rather than something external attached to them.

CHARACTERISTICS

The following table shows the main characteristics of all four of the tubes under review, and the reader can compare them with the corresponding characteristics



Perspective representation of the EC 55.

of conventional tubes, the comparison being an instructive demonstration of the differences between modern U.H.F. valves, and types which will not function at nearly such high frequencies.

	DC80	EC80	EC81	EC55	
Input capacity	1.25	5.4	1.7	2.2	$\mu\mu$f.
Output capacity	0.75	3.4	0.5	<0.02	$\mu\mu$f.
Grid-plate capacity	1.5	<0.06*	1.5	1.1	$\mu\mu$f.
Plate voltage	150	250	150	250	volts
Grid voltage	—3.5	—1.5	—2.0	—3.5	volts
Plate current	20	15	30	20	ma.
Mutual conductance	3.5	12	5.5	6.0	ma./v.
Amplificatn. factor	14	80	60	30	—

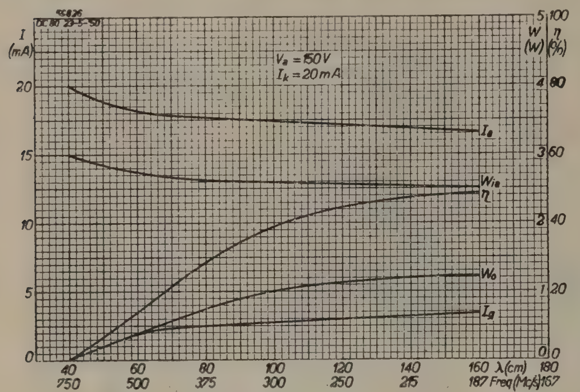
*In this case, plate-cathode capacity.

It will be noted that except in the case of the EC80, all the inter-electrode capacities are very low, in spite of the fact that the electrode clearances have been made very small. The figures for the EC80 show a comparatively large grid-cathode capacity of 5.4 $\mu\mu$f. This is due to the fact that in a tube designed for grounded-grid operation, this capacity can be higher than usual without causing difficulty, because the input impedance is always very low. In this tube it is of the order of 84 ohms, and at this low figure, the comparatively large input capacity has much less effect on the circuit operation than a very much larger capacity does in the ordinary case of grounded-cathode operation. By the same token, the plate-cathode capacity in this (and also in the EC55) is exceedingly small, showing how effective the grid is in its role of shield between the plate and cathode.

It should be noted that the figures quoted for plate and grid voltages in the above table are *not* ratings, but simply the appropriate values, representative of ordinary operating practice, at which hte tubes have the quoted figures for Gm and μ. It is necessary to state the plate and grid voltages at which these quantities are measured, since they vary with operating conditions,

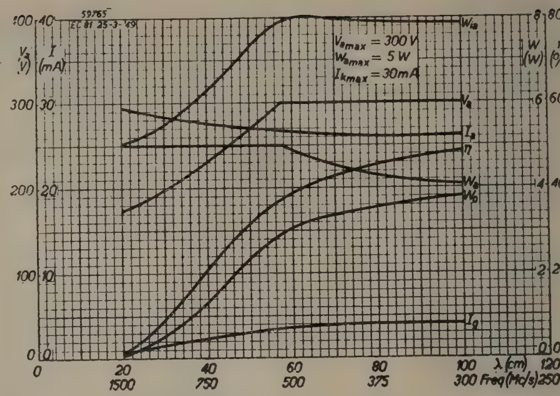
and are not strictly "constants," and any figures given without reference to plate and grid voltages and also plate current, would have no precise meaning.

All four tubes have a high value of mutual conductance, and although the figure of 3.5 ma./v. for the DC80



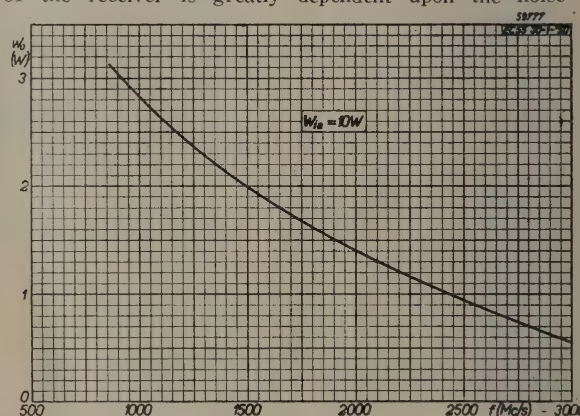
Operating characteristics of the DC80

is lower than all the others, it is remarkably high for a filament type tube, in which it is never possible to use such close grid-cathode spacing as in a tube with a rigid cathode sleeve. This high mutual conductance indicates that these valves will have stage-gains in proportion—that is to say, higher than those of more conventional tubes, with lower values of Gm. Another consequence of high Gm is that the tubes have a low equivalent noise



Operating characteristics, EC81.

resistance. This is not only much lower than that of R.F. pentodes or tetrodes, owing to the lack of the so-called partition noise, which arises in all multi-electrode tubes where the cathode current is shared between two or more electrodes, but is also considerably lower than that of conventional triodes whose Gm is lower. At the frequencies for which the valves are intended, this is a most important feature, since at U.H.F., the noise level of the receiver is greatly dependent upon the noise



Output versus frequency for the EC55.

generated by the tubes themselves unless this is considerably lower in level than that generated by thermal agitation in the tuned circuits, and in the aerial and feeder line.

Another feature of the tubes that is not brought out in the table above is their high plate dissipation for their physical size. For instance, that of the DC80 is three watts, and this enables it to have a useful power output, when used as an oscillator, of over one watt at frequencies below 300 mc/sec., dropping to 0.5 watts at 435 mc/sec. The EC81 has a plate dissipation of as high as five watts, and under the appropriate operating conditions can give an output as an oscillator of one watt at 750 mc/sec., and at lower frequencies, as much as 3.8 watts at 300 mc/sec. The EC55, as might be expected, has a higher power output still, and will give 2.8 watts at 1000 mc/sec., two watts at 1500 mc/sec., and one watt at 2350 mc/sec.

(To be continued.)

SHOES and SHIPS

"The time has come," the Walrus said,
"To talk of many things. . . ."

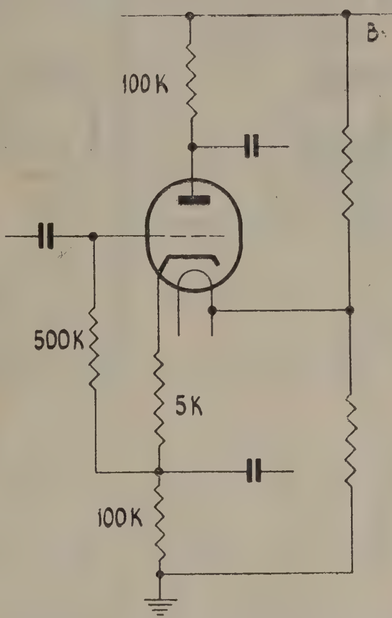
By Special Arrangement with the Walrus

This article is dedicated to all those radio servicemen and enthusiasts who at some time in their lives have attempted to remove hum from audio amplifiers or hash from vibrator-powered receivers.

The elimination of these unwanted additions to an otherwise satisfactory piece of equipment has proved a stumbling block to a whole host of radiomen and added another grey hair to the whitening locks! However, there are many things which may be done to minimize this form of trouble so we shall begin with the case of the humming amplifier or audio section. Strictly speaking hum should not be a great problem in low-gain equipment if normal precautions are observed, but the trouble really starts when microphone pre-amplifiers are included on a chassis which is shared by a power transformer and rectifier. The first obvious thing to do in this case is to keep as great a distance between the pre-amplifier valve and the power transformer as is possible. That usually means having the transformer at one end of the chassis and the valve with its associated circuitry at the other end. The next consideration is the actual type of power transformer itself. This, for best results should be of the vertical mounting type rather than the flat variety since the flat transformer really makes the chassis a large lamination to the inestimable joy of numerous eddy currents induced therein. Besides which the vertical transformer is so much easier to mount and means far less hacking about of chassis so we gain both ways. Filter chokes "where employed" should be mounted with their cores at right angles to that of the power transformer and situated also as far from the high gain section as possible. The "where employed" is intentional for it is the writer's belief that resistive filtering can prove every bit as effective in average amplifiers where extreme bass response is not necessary and where a certain amount of negative feedback is employed.

At this stage we can mention a point which although not of supreme importance, is nevertheless worthy of consideration, this being the chassis material. Steel, while making a good robust chassis, does conduct magnetic fields from the power supply very readily and adds to the problems of the unwary. Aluminium, on the other hand, is not troubled in this respect and is to be preferred by the person who is not well versed in the "anti-hum art."

Turning now from the constructional to the electrical side, one finds a variety of causes, cures, and preventions. Firstly, it is essential that all earthing points associated with each valve should be returned to a common point on the chassis. By this is meant that bias resistors and condensers, grid leaks and screen bypass condensers should be earthed at the same spot on the chassis. Failure to do this is one of the most common causes of hum encountered in audio equipment and until this exacting rule is complied with further efforts will only prove fruitless. Our second point, or rather an extension of our first consideration, is do not neglect the humble volume control. When all is said and done he is used in most cases as a grid leak so back his earth return must go to the earthing point common to that valve which he serves. We're sorry about that, but it has to be done and just for good measure if you are running a screened lead to the potentiometer, include the earthed lead inside the screened shielding for luck. It may seem fantastic

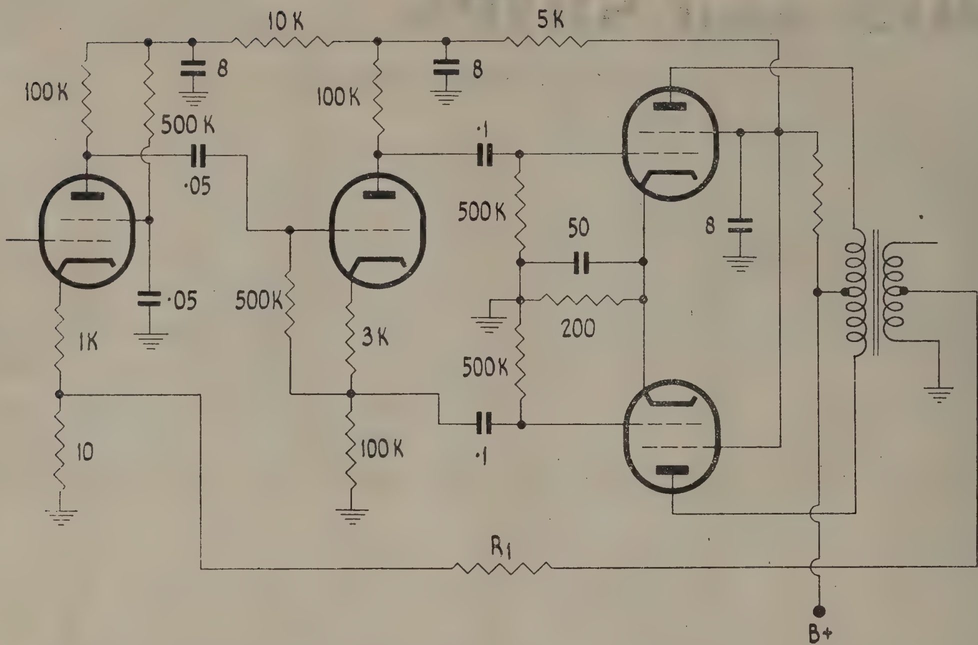


A well-known phase inverter that can introduce hum. Using a separate heater winding, and connecting it to a positive potential, as shown, can often effect a cure in this case.

that a lead at earth potential can pick up hum, but it has occurred before today where the lead is rather long.

Our next point concerns filament earthing. It is not just sufficient to earth one side of the filament or heater winding and then divorce it from your mind. Particularly in the case of high gain circuits is this factor critical. The earth should be applied to the pre-amplifier valve or that valve operating at highest gain, and try earthing either side of the heater to see which gives best results. If the answer is still in doubt connect a 100-ohm potentiometer across the heater and put the centre arm to earth. A little careful adjustment of the pot. will soon give the best position, and if the moving arm comes to rest about centre, two 50-ohm resistors may be used instead of the pot. Generally, they are easier to find a parking place for than a wire-wound pot. anyway. In persistent cases of heater-induced hum, applying a positive bias to the heater winding can effect a ready cure. This voltage should be higher than the highest cathode bias on any of the valves and may be derived from a divider from H.T. to earth as shown. Don't overlook the fact that a phase inverter of the lifted cathode type (see diagram) may have as much as 100 volts on the cathode and the filament bias should be higher than that.

The case of that type of phase inverter, however, is exceptional and it is really a better idea to run the filament of that valve from a separate heater winding and put the positive bias on that. By doing that all other valves in the amplifier are not running with a high voltage difference between cathode and heater with con-



A well-tried audio amplifier circuit with negative feedback. Typical valves are: 6J7, 6J5, and p-p 6V6's. The degree of feedback is regulated by the value of R_1, which, as explained in the text, is also dependent on the voltage at the point on the output transformer from which the feedback is taken.

sequent risk of breakdown or leakage between the two. Having complied with all these requirements your amplifier should now have only a minor purr left like the family cat at fifty paces and this figure can be increased to lots of paces ad. inf. by including about 4 D.B. of negative feedback over as many stages of the amplifier as possible. This will clear up practically all the hum remaining, but negative feedback should not be used to remove bad hum caused by faulty design—it must be regarded simply as the last refinement to the hum eliminating drill. Don't get too enthusiastic about the merits of feedback and increase it to large amounts, however, since this calls for very careful design and high-grade components. Generally speaking 4 D.B. is a good workable amount without incurring all manner of troubles on complex waveforms. The accompanying diagram is a well tried and effective circuit for degenerative feedback. The value of resistor R_1 will be dependent on the impedance tap used on the output transformer. For a 3-ohm tap it should be approximately 100–200 ohms.

Some Novel Applications

RADIO EQUIPMENT USED FOR LOCATING FERRETS

The normal method of catching rabbits with the aid of a ferret is subject to many difficulties. The ferret frequently stays underground, and as its exact position is almost impossible to determine, much time is wasted in digging it out. In addition, this loss of time leads to the mauling of the rabbit by the ferret.

The "Radio Ferret' equipment, manufactured by a Birmingham firm, has solved this problem by using the principle of radio location. A harness is fitted to the ferret, instead of the normal collar, and to this harness is fitted a very small coil. This coil is connected by means of a flexible wire, which is used instead of the oridinary line, to the ferret, and an electrical signal is transmitted to this coil by means of a vibrator worked off a small dry battery.

The pick-up unit consists of a portable combined aerial and receiving set, and a pair of headphones, and when it is required to find the ferret the signal is switched on, so that it is possible to locate it within two inches (50.8 millimetres). Location is easy down to eight feet deep (2.4 metres).

"SUITCASE" TELEVISION FOR MOBILE OUTSIDE BROADCASTING

Television equipment, normally bulky and "studio bound," suffers a great disadvantage when compared with news reel equipment which can be set up to cover outside events at a few moments' notice: An entirely new range of television equipment now produced by an Essex, England, firm, however, can be used for both studio work and for mobile outside broadcasts. All units can be carried in streamlined suitcases and the new camera marks many advances in television design it is claimed. A four-lens rotatable turret in which screw mounting is eliminated allows the quick setting up of lenses by a new clip-on method. The lens is operated from the rear and the vision output is automatically blanked when the turret is rotated. Focusing is done by racking the camera tube and deflection assembly relative to the lens. Control is by a single handle.

Extreme sensitivity of the new camera enables it to provide really good pictures by the light of a single candle and it will operate without adjustment over a wide range of varying light values. The camera is fitted with an electronic view finder in which is incorporated a small vision monitor so that the operator can see the actual image his camera is picking up.

ELECTRICAL RECTIFIER WITH ELECTRONIC ACTION

Conversion of alternating electrical current to direct current has become increasingly necessary in modern industry, and to meet this growing need a Surrey, England, firm has developed and improved a rectifier which is purely electronic in action. This method eliminates vibration and mechanical wear, and solves many maintenance problems.

The new instrument, the "Velotrol," is a development of the firm's well-known glass bulb rectifier, and comprises the normal transformer and rectifier together with the control gear. It enables the armature voltage and field current of shunt connected direct current motors to be varied either independently or together to give smooth speed variation over ranges of up to 50 : 1 or greater if required.

The rectifiers are made for operation on any alternating current supply in type to suit most industrial variable speed drives. Each type is designed for the particular application and the Velotrol operates with any standard direct current motor, thereby ensuring the highest overall efficiency both in operation and maintenance. Nothing is consumed within the bulb, which continues to operate indefinitely and, as no filaments are used, a warming up period is not necessary so that the bulb can be switched immediately on to the load.

"RADIO AND ELECTRONICS"

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The "R. and E." Gramophone Pre-amplifier

PART II (Continued from the February 1951 issue)

CONSTRUCTION—continued

The wave-change switch used for S_1 can be seen, in the centre of the chassis, and has its operating shaft 2½ in. from the end of the chassis. This brings it in a convenient position for connecting to the circuit of V_2.

It should be noted that the switch is mounted, not by the usual single-hole fixing, but by passing the long side-bolts through the chassis, and assembling the switch in position. Two of the wafers are placed above the chassis, and the remaining one below. The idea of this is to allow S_{1a}, S_{1b}, and S_{1c} to be above the chassis, where they are shielded from the plate circuit of V_3, which would be uncomfortably close if they were underneath. It also enables all the small parts comprising the parallel-T network to be placed above the chassis, making room below for some of the larger parts, including the cathode bypass condensers and the plate-to-grid coupling condensers.

In this connection it should be noted that the condensers and resistors of the parallel-T network are all mounted on the switch contacts themselves, and that several other small parts are also above the chassis, mounted on tag strips. These include all the parts between the grid on V_3 and the output of the plate network of V_2, and the parallel-T network in the plate circuit of V_3 itself. Two small tag strips have been mounted behind the switch, and these carry all the parts mentioned. The exact manner in which these are disposed is not very important, because of the low overall gain of the three stages, but the work should be carried out as neatly as possible, and we would strongly recommend that lugs be provided on the tag strips so that all resistors and condensers are able to terminate on one of the lugs, or else on one of the switch lugs. In this way, all parts are properly supported, and there is no chance of accidental short-circuits through shifting of the parts, and through loose soldered joints that are able to shift their position with respect to the rest of the wiring.

CHOICE OF SMALL COMPONENTS

It will probably have been noticed that contrary to our usual practice, tolerances have been marked against certain of the condensers and resistors. The reason for this is that the performance of the low and high-pass filters is to a large extent governed by the accuracy with which the values are chosen. It is quite possible to build the unit without choosing the parts with any special care, but if this is done, it should be remembered that the cut-off frequencies of the filters may not come within quite a way of the designed values unless the tolerances specified are adhered to. However, those who have no facilities for purchasing or choosing accurate values need not think that this makes the circuit entirely unpractical, for such is not the case. Tests have shown that quite acceptable performance can be obtained by using standard-tolerance components throughout, but that the attenuation above the cut-off frequencies will not usually be quite so great. The moral is, use parts that are as accurate as can be obtained for the ones where close tolerances are specified, but do not worry unduly if these cannot be obtained.

It is advisable to make a careful check of the wiring, especially that of the switch for the low-pass filter, before the unit is put to use. It is very easy to make wiring mistakes in a circuit like this unless great care is taken, and a little time spent checking before switching on may save many hours of searching to find the cause of some unpredictable behaviour.

HUM REDUCTION

This pre-amplifier is not suitable as it stands, for pick-ups with very low output, such as the moving-coil variety, or the variable reluctance type, which have an output of only 10 millivolts or so. Rather is it intended for medium output pick-ups of 0.1 volt output or more. It may be found that for pick-ups with only 0.1 volt output, the hum output, though tolerable, is not quite low enough for high-fidelity requirements. For the latter, it should be about 50 db. or more below the maximum power output of the amplifier with which it is to be used, and with the present design, this figure can be reached by means of a little attention to detail. The circuit as originally given three months ago, does not show what earthing arrangements are to be made for the heater wiring. It was found that the hum from the unit was such as to be equivalent to a hum voltage of 0.35 mv. when the following precautions were taken. At that, a pick-up with an average output of 0.35 volt would give a signal/hum ratio of 60 db., while one of 0.175 volt would give a ratio of 54 db. These figures are worked out on the average pick-up output, so that at

full signal input, the ratio would be slightly better, and at low signal levels, slightly worse than these figures.

The first thing to do is to install two 50-ohm resistors in series across the filament pins of the EF37, and earth the junction to the nearest possible point to the valve socket. This can conventiently be a solder lug held under one of the socket's mounting screws. Note that it will have been necessary to run a two-wire heater system, and to have left the heater circuit ungrounded, so that the centre-tapping by means of the 50-ohm resistors is the only ground on the heater circuit. This gives at the outset a much lower hum level than earthing one side of the heater wiring, as can be done in an ordinary amplifier chassis. The next step is to install at any convenient place in the chassis a low-resistance wire-wound potentiometer. Any value between 100 and 500 ohms total resistance will do. A good place for it is right at the heater winding terminals of the power transformer. The ends are wired to the heater winding terminals, and the centre connection is for the moment left unconnected. Then the screen bypass condenser in the EF37 circuit is disconnected from earth, and an insulated lug installed in a suitable position, and the earth end of the condenser taken to it. Finally, a wire is run from the moving arm of the low-resistance potentiometer to the screen bypass condenser (*i.e.*, to the end that has just been disconnected from ground. The preamplifier is connected up to the main amplifier, the pick-up connected to the input, and the potentiometer just installed is very carefully adjusted to the position that gives minimum hum output from the speaker. This will reduce the hum to a very low level indeed, and should be all that is required.

One point to watch is microphonic effect in the 6SN7 which makes up V_1 and V_2. It may be found necessary to try several valves until the least microphonic one is found for this position, but almost any 6SN7 can be used in the cathode follower stage.

GAIN FIGURES

The following figures may be found useful by those who have a vacuum tube voltmeter, and will serve to indicate whether the pre-amplifier is working properly. Figures within 20 per cent. or more should be regarded as quite satisfactory, since differences between the exact characteristics of the valves used will easily account for this range of performance.

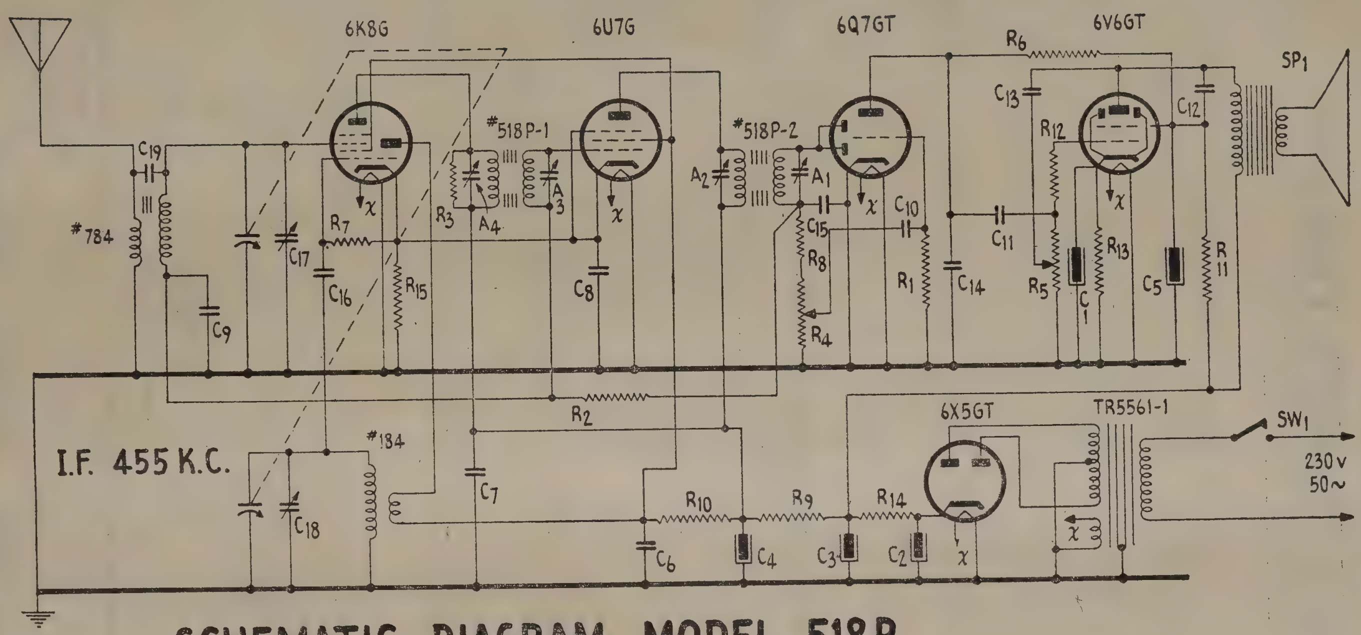
From input terminal to plate of V_1: 16.5 times.
From input terminal to plate of V_2: 2.9 times.
From input terminal to plate of V_3: 16.5 times.
From input terminal to cathode of V_4: 15.7 times.

It will be noted that the measured gain in V_1 is slightly higher than might be expected, but this could easily be accounted for by a rather higher amplification factor than normal in the first tube. There will also be noted an overall loss in gain from the plate of V_1 to the plate of V_2. This is accounted for by the attenuation network R_3, R_4, which produces a loss of approximately $13\frac{1}{2}$ times. Thus, with the overall loss from the plate of V_1 to the plate of V_2 of 5.7 times, it is apparent that the gain of the V_2 circuit, from grid to plate, must be 2.4 times. This low figure is to be expected, however, on account of the heavy feedback over V_2.

The pentode stage, V_3, also has a low gain as a result of the feedback that is applied over it, the figure working out at 5.7 times. It can be seen, therefore, that all stages except V_1 are working with a high percentage of negative feedback, and that as a result, the distortion produced at the signal levels that will be handled will be

(Continued on Page 48.)

FOR THE SERVICE MAN *Pacemaker Model 618P*



SCHEMATIC DIAGRAM MODEL 518P

VOLTAGE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
Conv.	6K8	O	O	160	80	—5	80	6.3 a.c.	3
I.F.	6U7G	O	O	160	80	3	160	6.3 a.c.	3
Det-AF.	6Q7GT	O	O	60	O	O	180	6.3 a.c.	O
Output	6V6GT	O	O	220	180	O	O	6.3 a.c.	10
Rect.	6X5GT	O	O	230 a.c.	O	230	160	6.3 a.c.	240

1. D.C. voltage measurements are at 2,000 ohm per volt—A.C. voltage measurements at 1,000 ohm per volt.
2. Socket connections are shown as bottom views.
3. Measured values are from socket pin to common negative.

RESISTANCE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
Conv.	6K8	O	O	.5 meg	.5 meg	50 K	.5 meg	O	150 ohm
I.F.	6U7G	O	O	.5 meg	.5 meg	150 ohm	.5 meg	O	150 ohm
Det-AF.	6Q7GT	O	O	.5 meg	.5 meg	.5 meg	.5 meg	O	O
Output	6V6GT	O	O	.5 meg	.5 meg	.5 meg	.5 meg	O	300 ohm
Rect.	6X5GT	O	280 ohm	Inf	280 ohm	.5 meg	O	O	.5 meg

4. Nominal Tolerance on component value make possible a variation of ± 10% in voltage and resistance readings.
5. Volume control at maximum, no signal applied for voltage measurements.
6. Resistance readings in B+ circuits may vary widely according to condition of filter capacitors.

TECHNICAL INFORMATION

COVERING

BROADCAST RECEIVER TYPE 518P.

COLLIER & BEALE Ltd., WELLINGTON.

TYPE SET—A.C. Superhetrodyne.

TUBES (Five)—6K8G Converter, 6U7G I.F. Amp., 6Q7GT Det.-A.F., 6V6GT Power Output, 6X5 GT Rectifier.

POWER SUPPLY—230 v. A.C. Rating, 40 watts.

TUNING RANGE—Broadcast 535-1700 K.C.

ALIGNMENT INSTRUCTIONS

To set pointer, fully mesh condenser and set pointer at last reference mark at left end of dial. Set volume control at maximum and keep output from signal generator no higher than necessary to obtain output reading.

Dummy Antenna	Signal Generator Coupling	Sig. Gen. Frequency	Band Switch Position	Radio Dial Setting	Output Meter	Adjust	Remarks
.1 mfd.	High side to grid of 6K8	455 Kc.	....	High freq. end	Across voice coil	A1, A2, A3, A4.	Adjust for maximum output
R.M.A. Standard	High side to ant. terminal	1400 Kc.	....	1400 Kc.	"	C18	" "
"	" "	1400 Kc.		1400 Kc.	"	C17	" "

CAPACITORS

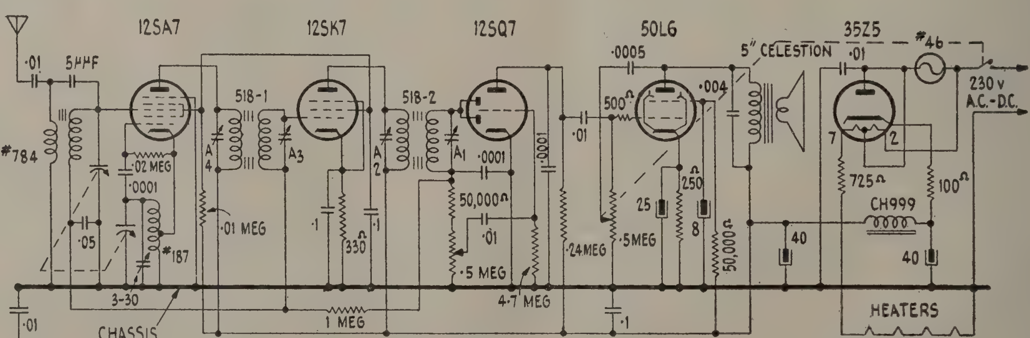
Ref. No.	Cap.	Volts
C1	25mfd	25
C2	10mfd	450
C3	10mfd	450
C4	8mfd	450
C5	8mfd	450
C6-8	.1mfd	400
C9	.05mfd	400
C10-11	.01mfd	600
C12	.004mfd	mica
C13	.00025mfd	mica
C14-15	.0001mfd	mica
C16	.00005mfd	mica
C17	3-30	trimmer
C18	3-30	trimmer
C19	5mmf	ceramic

MISCELLANEOUS

Ref. No.	Res., Pri.	Res., Sec.	
784	20 ohm	2.7 ohm	
184	1.8 ohm	2.3 ohm	
518P-1	6.75 ohm	6.75 ohm	
518P-2	6.75 ohm	6.75 ohm	
	Volts	Volts	Volts
TR5561-1	230	250 aside	6.3
	Type	Transformer	
SP1	5" P.M.	5000 ohm	
SW1	S.P.S.T. switch attached to R5		

RESISTORS

Ref. No.	Res.	Watts
R1	4.7 meg	½ watt
R2	1 meg	½ watt
R3	.5 meg	½ watt
R4	.5 meg	Pot
R5	.5 meg	Pot
R6	.25 meg.	½ watt
R7	.05 meg	½ watt
R8	.033 meg	½ watt
R9	.015 meg	1 watt
R10	.01 meg.	1 watt
R11	4,700 ohm	½ watt
R12	500 ohm	½ watt
R13	300 ohm	1 watt
R14	300 ohm	1 watt
R15	150 ohm	½ watt



I.F. 455 K.C.

SCHEMATIC DIAGRAM. MODEL 518.A.D.

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

AERIALS AND TRANSMISSION LINES

Microwave aerial radiation patterns. The paper describes an investigation of the degree of precision with which the side-lobe structure of fan beam aerials may be examined on typical field sites with a view to the design of radar apparatus. The question of site errors is discussed.

—*Wireless Engineer* (Eng.), January, 1951, p. 29.

AUDIO EQUIPMENT AND DESIGN

The article deals with refracting sound waves. One usually associates refraction with a continuous medium, but refraction can occur in a medium containing an assemblage of obstacles, such as spheres, disks, or strips. To refract sound waves the latter must be rigid and of small size. Practical examples are given.

—*Ibid*, January, 1951, p. 1.

A speech compressor and modulation monitor is described which is of the logarithmic type and features a meter calibrated directly in decibels of compression. The monitor indicates negative peaks by means of a flasher lamp, and a dial calibrated in terms of modulation percentage.

—*Radio and Television News* (U.S.A.), Jan. 1951, p. 41.

A satisfactory and economical answer to the problem of directional high-frequency sound radiation for loudspeakers is discussed. The design has a speaker mounted on top of a triangular column, and a reflector is used to direct the sound into the room.

—*Ibid*, January, 1951, p. 55.

To avoid disturbances caused in a gramophone pick-up system which is normally too close to its amplifier, one of the best solutions is to move the record playing mechanism to a distance from the loudspeaker system. A compact preamplifier with cathode follower output is the answer.

—*Ibid*, January, 1951, p. 58.

A practical approach to inverse feedback with a review of the advantages. Several proven circuits on how degeneration can be applied are also included.

—*Ibid*, January, 1951, p. 69.

Recent developments in speech reinforcement systems—the article is mainly concerned with the retention of the naturalness of speech and deals with short delay times, echoes with long delay times, and the application of the principles to theatre reproduction, etc.

—*Wireless World* (Eng.), February, 1951, p. 44.

CIRCUITS AND CIRCUIT ELEMENTS

Owing to the much larger bandwidth required for television and F.M. transmissions the frequencies used are considerably higher than those used for normal broadcast reception. The article deals wtih frequency changing at these higher frequencies and the circuitry of the frequency changers.

—*Philips Electronic Application Bulletin* (Holland), June/July, 1950, p. 105.

MATERIALS, VALVES, AND SUBSIDIARY TECHNIQUES

Here is a summary of the types and characteristics of capacitors commonly used in radio equipment. The basic types are given with the use for each type.

—*Radio and Hobbies* (Aust.), March, 1951, p. 40.

Although the practical uses of non-linear resistors are of more use to the power than to the electronic engineer their study is interesting. An exceedingly large current change is obtained by doubling the applied voltage across the resistor.

—*Radio and Television News* (U.S.A.), January, 1951.

This article deals with electrolytic condensers for A.C. which have two plates of aluminium covered with a layer of aluminium oxide and placed in an electrolyte. The properties are explained.

—*Philips Research Reports* (Holland), August, 1950, p. 250.

Substantial gains in light output can be achieved in TV tubes by the use of metallic films as a backing for the phospor to reflect light otherwise lost. The design is here considered.

—*Television Engineering* (U.S.A.), December, 1950, p. 12.

A miniature magnetron has been evolved not only for use in receivers as a local oscillator but also for many low-power oscillator applications. These have an output of 250 milliwatts and will find many uses.

—*Ibid*, December, 1950, p. 20.

Many ingenious methods have been evolved to simplify and step up chassis assembly, one of which involves die stamping of wiring out of a sheet of conducting metal substantially attached to insulating material.

—*Ibid*, January, 1951, p. 10.

A tetrode power amplifier for metric waves is described.

—*Philips Electronic Application Bulletin* (Holland), August, 1950, p. 149.

MATHEMATICS

This paper is primarily concerned with camera tube sensibility "a figure of merit" being found which expresses the performance of the valve.

—*Wireless Engineer* (Eng.), January, 1951, p. 4.

A continuation of an article on vector diagrams from the earlier issue. The treatment is simple and is intended for those who have not a complete understanding of the basic principles.

—*Wireless World* (Eng.), February, 1951.

MEASUREMENTS AND TEST GEAR

The uses of a pulse generator in the laboratory are generally well known, and a simple and inexpensive design of such an instrument should be welcome. A pulse rate of 100 to 200,000 pulses per second is provided for.

—*Radio and Television News* (U.S.A.), February, 1951, p. 36.

A direct reading electronic audio frequency meter is described, which gives direct indications of frequency to 50 kc/sec. The response is independent of signal waveform and is not affected by signal voltage fluctuations.

—*Ibid*, February, 1951, p. 54.

An electronic A.C. voltmeter. The instrument described measures A.C. volts from 1 mv. to 100 v., and has an impedance of .5 megohm. This is one of the indispensable instruments for the home laboratory and can be built at small cost.

—*Ibid*, February, 1951, p. 56.

A signal tracer is here described with a detector built into the probe which is coupled to an audio amplifier with a wide response. It is a very useful instrument for checking faults.

—*Ibid*, January, 1951, p. 61.

The measurement of vacuum by electrical methods was outlined in the earlier issue. This article deals wth Penning or Philips ionization gauges, and a comparison of the various types of gauges.

—*Electronic Engineer* (Eng.), February, 1951, p. 46.

Two designs of temperature controller for laboratory furnaces are described with details of the construction and circuitry.

—*Ibid*, February, 1951, p. 51.

The measurement of the speeds of revolution of rotating shafts can be carried out in several ways. A description is given of an electronic tachometer which operates from the alternating voltage generated by the rotating shaft.

—*Ibid*, February, 1951, p. 55.

By means of the simple equipment described in this paper the response of an impedance or network to a unit function of the current is traced on the screen of a cathode ray tube. The response of pulses of finite duration can easily be derived from the oscillograms obtained.

—*Philips Application Bulletin* (Holland), June/July, 1950, p. 134.

The use of R.F. test techniques with an instrument featuring one inductance test range and two capacitor test ranges has been found effective for locating capacitor and coil defects. The system is old in the art but is here revived.

—*Service* (U.S.A.), December, 1951, p. 21.

MICROWAVE TECHNIQUES

The construction of waveguides and connectors has to meet demands quite different from those required for larger waves. Special measuring apparatus and techniques are needed, and methods are here given of making the calculations.

—*Philips Technical Review* (Holland), July, 1950, p. 15.

PROPAGATION

The importance of obtaining warning of inoscopic or magnetic storms is emphasized. Varying amounts of advance warning are given of storms which can be used to prevent the disruption of communications.

—*Wireless Engineer* (Eng.), February, 1951, p. 43.

Car ignition radiation is here discussed with an advance of the theory of resonances in the ignition system, and some methods which help suppression.

—*Wireless Engineer* (Eng.), January, 1951.

RECEIVERS

An experimental V.H.F. service is now being radiated by the B.B.C. from Wrotham with simultaneous A.M. and F.M. modulation. Reports of tests with a home-made F.M. receiver are given.

—*Electronic Engineer* (Eng.), February, 1951, p. 49.

There is an interesting part of the radio spectrum between 100 and 200 metres which is outside the range of the ordinary receiver. The article describes a simple convertor which will bring in the lower frequencies.

—*Wireless Engineer* (Eng.), February, 1951, p. 67.

The servicing of F.M. detectors is outlined.
—*Service* (U.S.A.), December, 1950, p. 32.

TELEVISION

Finding your way around a TV chassis—step by step procedures are listed and a typical analysis for single chassis models.
—*Ibid,* December, 1950, p. 12.

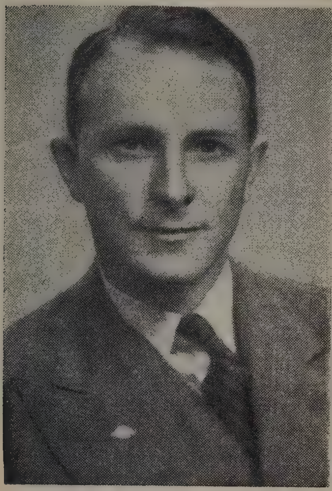
Television optics. The Schmidt system is described including the use of spherical mirror and correction plate. Some designs for the projection of television are given.
—*Philips Electronic Application Bulletin* (Holland), May, 1950, p. 95.

Theatre television as an entertainment medium has now reached the practical commercial stage and 7 in. projection tubes operated at 80,000 volts are being installed with projection to a 20 ft. screen. The success depends on the very high brilliancy of the phospor, and augurs much hope for the future.
Television Engineering (U.S.A.), December, 1950, p. 15.

Television synchronizing circuits. A description of several of the popular methods of sync. circuits used in modern TV receivers.
—*Radio and Television News* (U.S.A.), Jan. 1951, p. 71, and February 1951, p. 59.

TRADE WINDS

W. L. YOUNG, NEW PRESIDENT OF WELLINGTON RADIO TRADERS



Mr. W. L. Young

Although only closely associated with the radio business for the past five years, W. (Bill) Young, manager of Russell Import Co., Ltd., has a strong grip of affairs generally, and his appointment as leader of the Wellington Radio Traders' Association will be received with pleasure by all concerned. Two years on the executive committee has given him a good insight into the benefits that can be derived by organization. One of his endeavours for the near future will be to encourage greater membership of the Association. He also expresses the desirability that retailers be more to the fore in discussions on matters of mutual interest to the wholesaler and retailer. Mr. Young, as a returned serviceman (Middle East) knows what team-work can mean, and as the new leader for the Wellington radio trade, we feel confident that he will be a worthy successor of past presidents, who, over many years, some of them particularly difficult ones, have preserved the trade on a high level.

As a member also of the Council of the Wellington Chamber of Commerce, Mr. Young will have a broad knowledge of trading matters, upon which the Wellington traders will no doubt draw liberally.

* * *

Fire seems to have taken its toll of the radio world in recent months. The latest to suffer in this respect is Swan Electric Co., Ltd., Christchurch branch, who received much stock damage during the large conflagration there in April. New premises were secured within a few days and business as usual carried on at 69 Worcester Street.

* * *

Members of the staff of Cory-Wright and Salmon, Ltd., are doing well in keeping up the birth rate. I. C. Roberts, Advertising Department, and W. R. Barrington, Industrial Supplies, now have baby daughters, and R. E. McLauchlan, Waterworks Department, a young son, whilst T. M. Bryant, of E.E.A. Department, has a second daughter, bringing the roll to four C.W. & S. births in recent months.

* * *

Mr. C. W. S. Parker, a director of Cory-Wright and Salmon, has received fitting tribute from members of the staff on his completion of 25 years with the company. Mr. Parker has been closely associated with English electric plant and equipment for industrial, hydro-electric, and railway services. Amongst the major jobs was the first E.E. hydro-electric set at Lake Coleridge power station and subsequently at Waitaki, Highbank, and Tekapo. He has seen the electrification of New Zealand Railways progress from the eight-mile Arthur's Pass-Otira section, by English Electric Ltd. in 1923–24, to the Christchurch-Lyttelton and Wellington suburban areas.

* * *

Announcement

Electro-Technical Industries, Ltd., have advised this journal as follows: "As from 1st April, 1951, the management of this company will be under the sole direction of D. H. Heinemann. Formerly it was under the joint control of D. H. Heinemann and R. Wiseman. Mr. Wiseman has recently left the company. The registered office of the company will now be at 37 Kent Terrace, Wellington."

* * *

A recent visitor to *Radio and Electronics* was Mr. J. Hillier, of Morrinsville, who had some interesting items of experience to tell of his 2½ years in Great Britain and Europe. He left New Zealand in August, 1948, for a holiday trip, but like all radio enthusiasts, could not keep away from the "Know How Things Work" and was soon immersed in the throes of visits to many radio industrial concerns in Britain and later in Holland. Mr. Hillier says he acquired much knowledge of radio as applied overseas, experience that could not be obtained in New Zealand. Television techniques were of intriguing interest and so much so that he intends to get cracking in the electronics field again as soon as he can reorganize.

* * *

W. S. Green, known to the trade for many years, and late of Green and Cooper, Ltd., is opening a new wholesale company in Wellington to handle radio and electrical equipment. District representation will be available for special apparatus soon to be obtainable.

* * *

Traders' Federation to appoint a delegate to attend the manufacturers' meteings when questions affecting both interests are on the order paper. We understand Mr. D. B. Billing is the likely representative.

* * *

Bill Collerton and Doug King are branching out as a service organization called TV Radio Co., with premises on the corner of Levy and Brougham Streets, Wellington.

* * *

R. L. Dorreen, of Auckland Branch, has been appointed to succeed J. M. Griffiths as manager of N.E. and E. Co., Hamilton Branch.

* * *

Joining N.E. & E. Co. Head Office, Wellington, for an indefinite period is Mr. G. R. Owen, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., A.M.I., Mech.I. Sent from B.T.H. Co., England, Mr. Owen will assist in inquiries and contacts on behalf of that firm.

* * *

Ralph Wiseman announces the formation of "Wiseman Electric Company, Ltd." having taken over from Electro-Technical Industries, Ltd., the manufacture of the well-known "Oak" switches. The company's business is located at the original premises, 85 Vivian Street, Wellington.

In the April issue of this magazine we referred to a recent cocktail party by "Green and Cooper." This should have read Green and Cooper Ltd. Mr. W. S. Green has called our attention to the omission of the word "Ltd." and that as worded, it might be assumed that he was associated with the function mentioned, which was not the case. As has been previously announced in this magazine, Mr. Green severed his connection with Messrs. Green and Cooper Ltd. some months ago, and we regret any possible misunderstanding that may have arisen.

One of the most up and coming firms in the radio trade is Autocrat Radio Ltd. This going concern, started off by three ex-servicemen, has now overcome a major handicap under which it has laboured for a number of years—namely shortage of space—by the acquisition of their own building in a good position on the Great South Road leading into Auckland. The new premises are modern and spacious, well lit, and fitted with up to date working facilities. Staff are well provided for with modern lunch-rooms and other amenities. George Benson, Pearce Wills, and Roy Walker, the three principals of Autocrat Radio Ltd., now feel that they really are in business at last and are set "to go places." From all reports we hear about sales of Autocrat Car Radios they've been "going places" with their excellent product for some considerable time. Good luck to these young men who are showing enterprise and skill in both manufacturing and marketing.

* * *

PUBLICATIONS RECEIVED

Green and Cooper, Ltd.: Binder of descriptive leaflets from Airmec Laboratories, Ltd., England, covering signal generators, meters, oscillators, and other instruments.

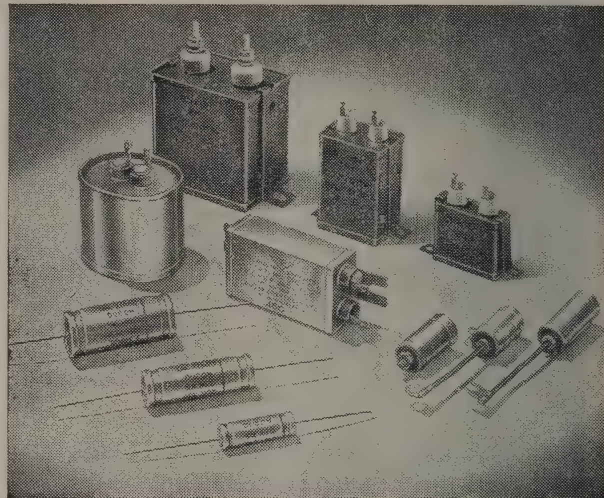
Philips Electrical Industries of N.Z., Ltd.: Philips Technical Review, June-July, 1950. Electronic Application Bulletin, August, 1950.

Industrial Electronics, Ltd.: "Particular Problems in Electronic Machinery," by W. Mackie & Co., Ltd.

Electronic Navigation Ltd.: Decca News, October-November, 1950.

Cory-Wright and Salmon, Ltd.: "Enterprise," March.

Grover Electric Co., Ltd.: Catalogue "Energo" Products.



THE "R. & E." AMATEUR TELEVISION PROJECT
Part V

SUMMARY OF PROGRESS

Needless to say, our own laboratory work on this Project is kept, as it were, several jumps ahead of the description presented in these pages. The business of month-by-month publication makes this state of affairs a necessity, and it is for this reason that we are able to report, here and now, that we have succeeded in producing our first satisfactory pictures. They were obtained using a VCR112 cathode ray tube as the flying spot light source, with a raster large enough to cover a 2½in. x 3½in. photographic negative, and an actual negative was used as the source of scenic material. This was viewed by the 931A electron-multiplier photo-cell, which was followed by three stages of video amplification using 6AC7 tubes. These were provided with shunt peaking coils to extend the frequency response to approximately 4 mc/sec., and the last stage was fed to the grid of the receiving tube, which was a VCR97. The time base circuits were those which have already been described, and later modified in accordance with the circuits to be presented in this instalment.

The definition obtained was approximately equivalent to that of a 200-line picture, and was good enough to show a considerable amount of detail—much more, in fact, than one would expect to be available from so small a number of lines. It is intended to go into this at a later date in more detail, since the question of just how the detail is produced is a most important one. Indeed, the observation on the actual receiving screen of the results of making certain organized changes in the equipment is of absorbing interest, and gives a better insight into the mechanics of picture reproduction than can any amount of reading. At the same time there were certain imperfections in the system that prevented a better resolution than 200 lines from being realized. We have our own ideas about this, but until further work is done, it is not possible to say whether it is due to inherent limitations in the gear being used, or to factors within our own control. It will be very interesting, for instance, to find out whether the size of the spot of the transmitting tube is the limiting factor, or whether better results could be obtained by varying the frequency response of the video stages in such a way as to compensate for the decay characteristic of the screen material on transmitting tube rather better than at present.

We mention all this, because followers of the Project will no doubt be interested to hear of our own progress, and also to point out that even if present limitations turn out to be outside our control, short of obtaining different equipment, readers who wish to duplicate our own equipment can rest assured that they will find the trouble well worth while. A 200-line picture is by no means to be sneezed at as far as reproduction of detail is concerned, and will be found of immense interest by anyone who may be keen enough to construct the gear.

ALTERNATIVE TIME-BASE CIRCUIT

In the last instalment of this series, we mentioned that the successful transmitting tube, the VCR112, has a much smaller deflection sensitivity than the VCR97 that we can use for the receiving end. Because of this, greater deflecting saw-tooth voltages are needed if the raster is to fill the screen. It might, of course, be asked why it should be desirable or necessary to fill the screen in any case, since a smaller raster merely means that a small transparency can be accommodated, but there is a very good reason for using as large a raster as possible. The present state of the prototype equipment gives a very good example of this very point. The trouble is, that the spot which scans the picture is not infinitely small. Ideally, it would be at all times smaller than the spacing between the lines of the raster. If it is not, it is highly probable that however good the rest of the equipment may be, the picture will not show as much detail as it should. It is obvious enough that no picture detail can be resolved (*i.e.* seen as a separate entity) unless it is larger than the size of the scanning spot itself, and this will determine the smallest detail, in a direction parallel with the lines of the raster. And since the aim should be to have approximately the same resolution both parallel to the line direction, and at right angles to it, there is no advantage in having more lines than can be separately distingiushed when the raster is viewed from a very close range. Now, for a given cathode ray tube, at given operating voltages, the size of the spot can be taken to be the same, at whatever part of the screen it happens to be, so that if the raster is very small, the lines cannot be distinguished, and much detail is lost.

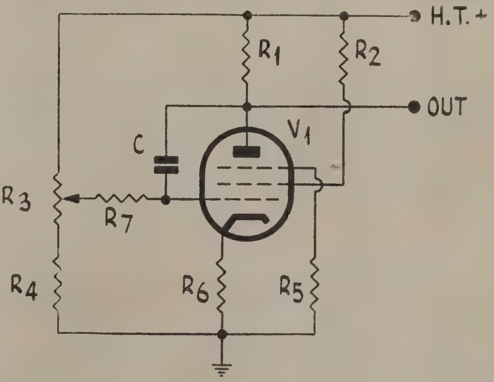


Fig. 5.—Alternative line T.B. circuit. Values are for 6AC7.

R_1, R_4, R_5, 50k.	R_6, 1k.
R_2, 60k.	R_7, 200k.
R_3, 100k. pot.	C, 0.002.

Suppose, for example, that we have a spot of diameter 1/100 in. This would actually be a pretty good one, but the figure will serve as an illustration. Suppose further, that the raster is only one inch high. In this case, it would be of no use employing more than 100 lines, because if more were used they would overlap, and detail in the vertical direction that was smaller than 1/100 inch high could not be reproduced. But if the raster is made 3 in. high, on the face of the same C.R.T., then it would be possible to resolve 300 lines vertically, and a 300-line picture could be used, and improved definition and detail would actually be realized. It is for this reason that we should make every effort to fill the screen of the transmitting tube with the raster.

In the case of the prototype equipment as it is at the moment, it is not considered that the spot is anything

(Continued on page 44.)

NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

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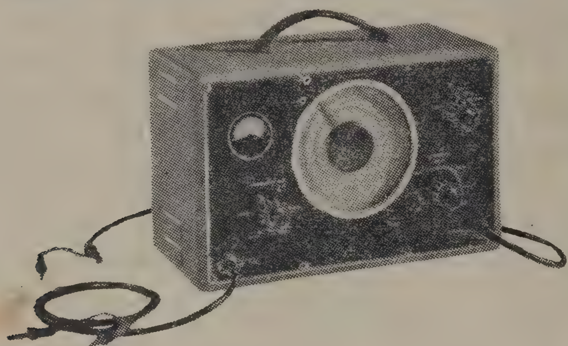
THE PHILIPS MODULATED H.F. OSCILLATOR GM 2883



Description:

This instrument, having a wide frequency range (100 kc/sec. to 30 mc/sec.) is designed for communication laboratories, radio receiver manufacturers and radio repair workshops. Its frequency stability and the absence of interference effects—for instance, frequency modulation and high-frequency leakage often found in similar apparatus—are outstanding features of this signal generator, which is to be considered as an inexpensive standard signal generator. It consists of a variable H.F. master oscillator, a low frequency oscillator and a H.F. modulation stage. A special H.F. range of 400–500 kc/sec. enables checking with a high degree of accuracy the intermediate frequency stages of receivers. A particularly large dial makes it easy to read the adjusted frequency, while the L.F. oscillator gives fixed frequencies of 400 and 2500 c/sec. and modulates the H.F. signal at a modulation depth of 30 per cent. The modulated H.F. signal is fed to a calibrated attenuator, the output voltage of which is conducted by means of a cable and standard dummy aerial to the equipment under test. The dummy aerial is of convenient dimensions and is easily detachable from the cable. The cable is also easily detachable from the apparatus and has a low capacity per unit length.

The L.F. signal is available at a concentric plug socket for testing audio frequency amplifiers, its voltage being controlled by means of a potentiometer.

An output meter is provided and this meter may be used:

(a) For adjustment of the correct H.F. output voltage on the attenuator.

(b) For adjustment of the correct L.F. voltage.

(c) As an output meter, for trimming receivers.

External modulation of the H.F. signal is also possible and when applying external modulation a built-in amplifier is used, so that the required modulation voltage is small.

Brief specifications are:—

Frequency Ranges:

(1) 100-300 kc/sec.
(2) 300-1000 kc/sec.
(3) 1-3 mc/sec.
(4) 3-10 mc/sec.
(5) 10-30 mc/sec.
(6) 400-500 kc/sec.

The ranges amply overlap each other.

Frequency Tolerance:

Ranges 1-5: 1 per cent.
Range 6: ± 1 kc/sec.

Frequency Stability:

Variation with 10 per cent. mains fluctuation is less than 0.02 per cent. ±. Variation with a change of 10°c. in ambient temperature is less than 0.1 per cent.

Full technical data and specifications available from:—
Philips Electrical Industries of New Zealand Limited, Auckland, Wellington, Christchurch, Dunedin.

* * *

THE ULTIMATE BREAKFAST GRILLER

The versatile and attractive new Ultimate breakfast cooker, is an all-purpose Ultimate appliance, ideal for cooking of small meals and most suitable for flats, baches, and caravans. Made of formed aluminium with a highly polished metal top, it is fitted with a new inconel tubular element which gives quick heating and is absolutely safe electrically. The Ultimate griller is finished in pastel shades; has cool moulded handle and feet and is supplied complete with reflector and grilling tray.

Specifications:

Rating: 1000 watts.
Power cable: Six-foot flexible with durable appliance plug attached.

Amateur TV

(Continued from Page 41.)

like as small as a hundredth of an inch in diameter, and the raster used was only about 2 in. in height. Thus, by making the raster taller, and at the same time correspondingly wider, much more detail should be rendered visible, as long as the transparency is also enlarged so that it still occupies the whole of the new raster. If the raster is enlarged, and the transparency remains the same size as before, then detail will actually be lost, because many of the lines will fall outside the limits of the picture, and can contribute nothing towards it. It is equivalent to reducing simultaneously both the number of scanning lines and the bandwidth of the video system, so that both horizontal and vertical resolution suffer to the same extent. It is to be expected, therefore, that when the raster on the prototype equipment is enlarged, and the transparency with it, considerably more detail should become visible.

The provision of greater scanning saw-tooth amplitude will mean the addition of a further stage of amplification after the line time base circuit. What is wanted is not more voltage gain, but greater output capability, so that a larger undistorted output voltage can be fed to the deflecting plates. It will, in fact, be necessary to add a push-pull stage, using larger tubes, and probably the most suitable ones will be 6V6s, or similar output valves. Because of this addition to the already rather large number of valves in the scanning circuit, it has been decided to give a less complex line time-base generator circuit, that will actually do as good a job as the more complicated one using the thyratron one already described. It can readily be made to work with any of the high-mutual-conductance pentodes, such as the 6AC7, the EF50, or the EF42. Its circuit and values are give on this page. R_3 is a potentiometer which enables the frequency to be

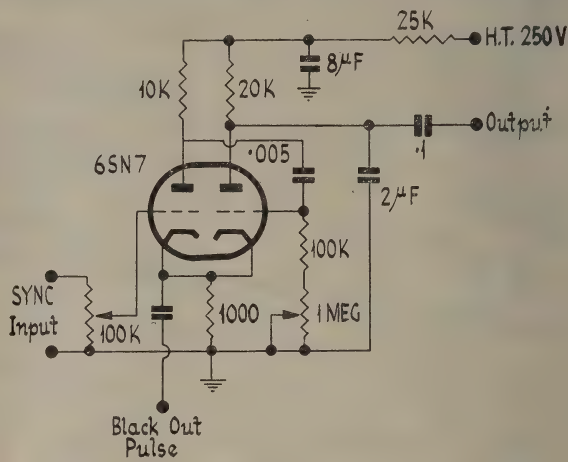


Fig. 6.—A satisfactory alternative frame T.B., giving a good pulse at the cathode for black-out purposes. It may easily be synchronized with the mains frequency by attaching the synch. input terminal to the heater winding. The circuit of Fig. 5 could also be used for the frame T.B. by changing R_7 to 1 meg. and C to 0.05 μf.

varied over quite a wide range, and will be found very useful, especially after the pictures have first become a reality. The condenser C can be used to give large frequency steps, but this facility is not needed in the present application. The output is more than sufficient to swing the grid of the amplifier and phase inverter stage, and the circuit can be directly substituted for the oscillator and thyratron circuit in the original diagram of the deflection unit. The linearity is very good indeed at high frequencies, such as are used for the line time-base, so that there will be no left-to-right shading of the picture owing to variation in speed of the scanning spot as it travels from one end of the line to the other.

Fig. 6 shows a simple circuit which can be used as the frame time-base. It has a terminal to which a synchronizing input can be applied, and this is very handy, as will be explained in a moment. It also produces quite a good blackout pulse across the cathode resistor, so that none of the advantages of the more complex original circuit are lost. The charging condenser must be large if linearity is to be good, and no less than the 2 μf. shown should be used.

Fig. 7 shows the power supply circuit, as used for the VCR112 transmitting tube. It is quite straightforward and needs little comment. It was used in the form shown because we had a high voltage transformer with a 2400-volt secondary and wished to make use of it. There are several other ways of obtaining the necessary high voltage for the cathode ray tubes, and we will devote some space to them later, because it is possible to do the job more cheaply than directly from a mains transformer in this way, and with more safety, too.

(To be continued.)

The New Zealand Electronics Institute (Inc.) Newsletter

General News

A meeting of the Dominion Council was held on the 3rd April last when a full quorum was present to deal with all business. Members will be pleased to learn that various trade organizations connected with electronics have very kindly made donations again this year to the Institute funds. Last year £160 in total was donated by different firms and a special arrangement has been made with the Commissioner of Taxes whereby grants made to the Institute in this way are deductible items up to the sum of £25.

Institute Insignia

Much progress has been achieved with regard to the Institute insignia and a block is in course of preparation; it is hoped that the Institute crest will in future appear at the head of these notes.

Television Lectures

It is hoped in the near future to arrange for a series of television lectures and a sub-committee has this matter in hand for implementation.

Decease of Members in Aircraft Accident

An appropriate resolution recording the unfortunate decease of Messrs. Pryce and Nicholls in the recent aircraft accident was passed. Both these members took a prominent part in Institute affairs and sincere sympathy with the relatives has been expressed by means of a suitable letter.

Accessions to Branch Library

There continues to be received in the mail considerable quantities of electronics and other literature and in particular our grateful thanks are extended to Philips Electrical Industries Ltd. for the many fine publications forwarded regularly.

●

In the absence of branch notes this month, we are printing the following short article, which we feel sure will be of considerable interest to members of the Institute.

PLASTICS IN RADIO

The rapid growth of radio has been largely dependent upon the products of the plastics industry and conversely the fact that an assured market existed for these products stimulated further development in the plastics industry itself. The compactness of the receivers, and therefore the possibility of mass-producing radio cabinets, were due, in great measure, to the electrical insulation properties of the plastics materials. Further, the widespread use of plastics materials for components is also largely due to their electrical properties and to their formability, leading to mass production of small components.

Research in the plastics field was intensified during the war years and the results of this work have manifested themselves in the development of new materials, techniques, and applications, which are to be the subject of the British Plastics Exhibition and Convention to be held at Olympia, London, from June 6 to 16, 1951.

Perhaps the most outstanding development has been the extended use of polythene, with its excellent dielectric properties, in the field of radar.

Plastics materials now in use in the radio industry embrace both the thermo-setting and thermo-plastic

groups. The thermo-setting materials include phenolics, cast phenolics, laminated phenolics, urea-formaldehyde, and melamine formaldehyde.

Recently injection moulding has been widely adopted with the development of larger machines, components including complete cabinets have been successfully produced. Injection moulding materials commonly used include cellulose-acetate and cellulose acetate-butyrate, polystyrene, polymethylmethacrylate, vinyl materials, and polythene.

The major components of a radio set resolve themselves naturally into three groups: the cabinet and fittings, the control and external switches, and thirdly the internal components.

Cabinets are compression-moulded in phenolic and urea formaldehyde material (used where light colours are required), and injection moulded in polystyrene and cellulose acetate-butyrate. The latter material is used for cabinets because of its good dimensional stability and its high surface finish.

Knobs and switches which were originally only moulded, in the thermo-setting materials, are now produced in a wide range of plastics. In some instances composite knobs are produced by injection moulding a cellulose acetate core into a clear polystyrene ring, giving a two-colour effect.

The widest field of application for plastics of both groups is undoubtedly in the components themselves. There is practically no internal component in which one or other of the plastics materials does not fulfil a specific function.

P.V.C. is widely used for insulating connecting wires. In the co-axial type of cable used in television receivers the two conductors are commonly insulated with polythene and encased in a polyvinyl chloride sheath.

Polystyrene is used for stand-off insulators and coil

formers. It is also used, in the form of tape, for insulation binding. Phenolics, both in compression moulded and laminated form are used extensively for covers, terminal panels, trimmer knobs, mountings, transformer cores and coil formers.

Recently polytetrafluorethylene became available to the radio industry. This material, although comparatively expensive, has exceptional dielectric properties which, combined with its ability to withstand high temperatures, has made it eminently suitable for such components as V.H.F. valve holders and as a covering for H.F. wiring in situations exposed to heat.

An excellent example of the use of plastics materials in radio is afforded by a recently introduced British portable radio, the cabinet of which is a one-piece polystyrene moulding weighing 20 ounces. The carrying handle is an integral part of the moulding, and in each of the four corners, conical tapered ribs not only give added strength but provide bosses holding inserts for bolting in the chassis. The injection port or sprue is centred in the handle, and when removed and subsequently drilled forms a convenient cavity for carrying the maker's symbol, which is separately moulded and gilt sprayed.

Of the ancillary components which complete this set, the injection moulded polystyrene grilles are the most interesting. These are moulded to the sizes required; three are needed, one for each side and one beneath the handle. The grilles are cemented into position using a quick-acting cement based on methylene dichloride. Bushes punched from phenolic laminate are used to provide insulation between the chassis and the cabinet.

The illuminated tuning scale is moulded in clear Diakon acrylic material, giving a lens effect on the moulded-in wave bands. After a silvering process is applied to emphasize the characters and numerals the scale is given a sprayed background colour to harmonize with the colour of the receiver case which is in green, cream, or maroon.

A polystyrene frame or escutcheon, which holds the tuning scale, is bolted to the set and the bolt holes conveniently concealed by polystyrene washers fitting behind the control knobs.

The two control knobs are produced in a double-moulding operation. The rims are first injection moulded in clear polystyrene, drilled to the correct diameter and then the opaque core, colour matching the housing, moulded in. Wave band changing is effected by a polystyrene

lever fitted beneath the tuning scale, with a knurled end projecting from under the set.

Finally the cabinet feet are provided by black moulded polythene covers which are non-perishing and more economical to produce than rubber components. The use of polythene brings the total of plastics materials up to four—polystyrene, acrylic, phenolic laminates, and polythene.

At the exhibition in London the exhibits will be in three main classes—materials, manufactured products, and plant and equipment.

Distortion Analyser

(Continued from Page 10.)

output which is being indicated on the meter. The nature of this residual reading can be readily determined by the use of the search oscillator. With the distortion meter operating as above in the "Read" position, the search oscillator is connected to the audio transformer input leads and enough search signal is injected to about double the residual reading on the meter. The frequency range of the test signal and its harmonics is then explored by varying the frequency dial of the search oscillator slowly. If there is a large beat fluctuation of the meter pointer at the fundamental frequency and little at its multiples, the residual reading is caused by imperfect bridge balance. If the converse is true, the harmonic content of the test oscillator is to blame for the incomplete null. The harmonic output of the test oscillator should be carefully recorded so that it can be discounted when actual amplifier tests are being made.

In using the bridge to analyse the distortion introduced by an amplifier, the procedure followed is the same as that used above for determining the distortion content of the oscillator except that the amplifier is introduced between the test oscillator nad the bridge, as shown in Fig. 3. The bridge input leads are connected directly across the speaker voice coil or other normal amplifier load. The gain of the amplifier is set to the value at which it is desired to determine the distortion. The null reading is then obtained as above and, expressed as a percentage of the full scale reading of the meter minus the residual reading, is the total distortion percentage introduced by the amplifier. The harmonic components may then be individually identified by the use of the search oscillator. Each beat noted indicated a component of that frequency (read from the search oscillator) and relative magnitude present in the output of the amplifier.

*R. F. Turner, Radio and Television News, Nov. '48, p. 69.

V.T.V.M.

(Continued from Page 8.)

the meter reads 300v. peak, as it does at the upper end of the highest range, the actual D.C. voltage applied to the meter tube is only 120 volts, so that a reasonably low H.T. voltage can be employed.

(To be continued.)

Up the Garden Path

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